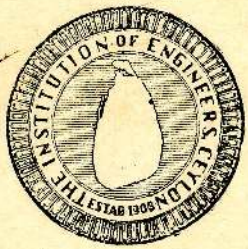
THE

INSTITUTION OF ENGINEERS

CEYLON



TRANSACTIONS FOR 1969

(VOLUME - II)

M. Thillainathan B

'To promote the acquisition and interchange of technical knowledge among Engineers and Members of allied Professions and to Regulate Professional Activities'

THE INSTITUTION OF ENGINEERS CEYLON

(Formerly The Engineering Association of Ceylon. Established 1906. Incorporated by an Act of Parliament in 1968.)

TRANSACTIONS FOR 1969

(VOLUME - II)

This Institution does not, as a body, hold itself responsible for statements made or opinions expressed either in the Papers read or the discussions which have occurred at the Meetings.

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Honorary Secretary.

PUBLISHED BY
THE INSTITUTION OF ENGINEERS, CEYLON
LOWER CHATHAM STREET,
COLOMBO 1.

PRINTED BY
THE WESLEY PRESS, WELLAWATTE,
COLOMBO 6.

CONTENTS

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To ensure the prompt delivery of the Annual Volume of Transactions and of other communications from the Institution, it is essential that every change of Address be notified to:

The Honorary Secretary
The Institution of Engineers, Ceylon,
Lower Chatham Street,
Colombo 1.

THE INSTITUTION OF ENGINEERS, CEYLON

President's Introductory Address

Dr. Malalasekera, Dr. Rowe, your Excellencies, Ladies and Gentlemen.

It is my pleasant duty today to introduce to you our Chief Guest and our Guest Speaker. The Chief Guest, Dr. Malalasekera, Chairman of the National Council of Higher Education, needs no introduction to an audience in Ceylon. He had been a leader in the educational field and our cultural ambassador abroad. It is with great pleasure that the Council decided to invite Dr. Malalasekera to open the 63rd Annual Sessions of the Institution of Engineers Ceylon. We are very grateful to Dr. Malalasekera for accepting our invitation to open the sessions of this Institution. I am sure you will be waiting to hear his valuable opening address and therefore I do not want to take much time.

I must say also just a few words about our Guest Speaker who has come all the way from England to grace this occasion. Dr. Rowe would be well known to all Civil Engineers, specially in the branch of concrete. As Director of Research of the Cement and Concrete Association in England which leads in research in cement and its applications, it was a great pleasure for me to have been able to invite Dr. Rowe whom I have known for about 12 years. I have been following his work carefully and meeting him at the Research Laboratory and I can assure you he is a great authority on the subject of concrete and concrete structures. Practically every student of Civil Engineering who has proceeded to the U.K. for post graduate studies would have come across him specially in the training courses at the C & C.A. Laboratory. I must thank him for having come all the way to be our Guest Speaker. I must also thank Their Excellencies the Ambassadors and the High Commissioners who have graced this occasion. I have now great pleasure in inviting Dr. Malalasekera to declare open this Session.

INSTITUTION OF ENGINEERS, CEYLON

Opening Address

by Professor G. P. Malalasekera
(Chairman, National Council of Higher Education).

Mr. President, Your Excellencies and Gentlemen,

I consider it a very great honour and privilege to be asked to open this 63rd Annual Sessions of the Institution of Engineers, Ceylon, and to give the Inaugural Address.

Indeed, one might well wonder what I a mere layman, nurtured in the Humanities, am doing in this august assembly of scientists and engineers. The reason probably is that it is not I who am being personally honoured but the post which I happen at present to occupy.

Engineering is not a new thing. It has been said that, in a very real sense, civilization itself depends on the engineer, for Civilization begins when people gather in cities. In fact, the word civilization is etymologically connected with cities and cities cannot exist without engineers.

Thousands of years ago men were confronted with the same basic problems as challenge engineers today—water-supply, communications, defence, the design of large structures and so on, and engineers of every age met these challenges and were able to find satisfactory solutions.

We ourselves in Ceylon have a long and proud record of such achievements, going back to several centuries B.C. Large irrigation and water-supply schemes, the gently graded man-made canals which took their water through many miles of undulating terrain to distant towns and reservoirs, our unique system of sluices, the highways, paved and bridged to suit the requirements of the traffic of the day; the fortifications, complete with moats and ramparts, some built in Cyclopean stone masonry, the immense religious and secular edifices, provided even with drainage, the numerous bathing pavilions and ponds with suitable inlets and outlets—all these and many more such examples evoke the unstinted admiration of even the modern engineer and provide standing monuments to the genius and outstanding ability of our ancestors. The genius and ability are still there, in spite of all that has happened in the many intervening centuries.

It is almost a truism to say that engineering dominates many fields of activity which are the focal points of the economic development of all nations, rich or poor, large or small, already developed or yet developing.

We have the Planning Engineer for the overall planning of the economic overheads or infra structure of economic development; the Irrigation Engineer making arable the land that was once arid; the Agricultural Engineer seeking avenues for self-sufficiency in food; the Chemical Engineer providing a variety of new materials for industrial purposes; the Industrial and Production Engineer, striving to achieve goals of high perfection compatible with economy and competing for external markets; the Structural, Electrical and Mechanical Engineers, the Electronics Engineers, who make possible the use of electronacally controlled apparatus, computers, supersonic aeroplanes and spacecraft, the Bionomic Engineer who specialises in medical engineering and the connected human factors and so on, in an almost infinite variety of categories, each category specialising in a particular field of activity. The age of "Mr. Know All" who was conversant with every detail of a job and controlled each step in its development is now no more. In his own day, through methods of trial and error and data found in handbooks he achieved wonders, and had to be admired for that.

In a poor country like ours, we cannot have the luxury of specialists which rich countries can afford. Yet we have basic needs that must be provided without delay, for example irrigation and agricultural engineering, industrial development, planned and promoted with foresight, adequate housing with as far as possible cheaper local material, better and cheaper transport facilities, a co-ordinated expanded and efficient system of road and rail services, supply of adequate and cheap electric power, improvement of harbour facilities; adequate water supply and sewage disposal. These and many more needs exist crying for immediate attention and here our engineers have to play a most important role.

I have a kind of feeling that we are too prone to regard economists as the high priests of modern society and have, in the process, rather neglected to give due honour to the overwhelming contribution which engineering science has made to the modern world. It is true the political and economic unification of small states into a large unit like Germany or the U.S.A. has helped in the production of mass markets and the expansion of prosperity. Yet unless the engineering skills had produced a cheap motor car the genius of Henry Ford was unlikely to have given the common man an automobile. Unless the engineers had so improved technology, high quality music would still be the preserve of lords and ladies or their equivalents in Society. Unless there had been such marvellous advancements in textile technology

and the petro-chemical industry, fine clothes, as are now commonly worn by even the poorer members of our Society, would have been the prized possessions of those that wore muslins in the 19th century. Thus, while we laud the adventure of astronauts in landing on the moon and in attempting to build space-platforms to be put into orbit, we should not, I feel, neglect to praise the contributions made by engineers and scientists to reduce the harshness of conditions of life in poorer societies.

I also feel that the activities undertaken by an engineer in a country like ours tend to be different from those of his counterpart in a rich society. It is inevitable that in the present context many, if not most, of our engineers, like our economists and even our administrators, are trained abroad, generally in Europe or North America. It often happens that persons trained in rich countries carry back to their own poor countries concepts of work and conditions of pay and other amenities which obtain in the affluent nations. It is not for a moment argued that these conditions if they could be made available would not be all for the good.

But, in a world of hard facts, we have to be realists and we have by now learnt that poor societies are short of capital. It is also known that many poor societies like Ceylon certainly have abundant mans power supplies. This would immediately raise for the engineer returned from abroad an unfamiliar yet challenging problem. Thus, an engineer who learnt sugar technology in the U.S., or Australia may find that if he recommends the same technology in Ceylon he creates an additional problem of technological unemployment. The need, therefore, arises that some means should be found to prevent this happening.

The Ceylon engineer thus becomes also an innovator. Nor is that all. In a country like ours where the education system has so far failed to provide an adequate supply of skills complementary to those of the engineer, the engineer finds the need to reassess his task. It would indeed be unfortunate were a patient allowed to die because his doctor did not have at his command the services of para-medical personnel to help him in his diagnosis and treatment. In such an eventuality each doctor would perhaps become his radiologist and pathologist. Even more versatility would be demanded of an engineer in countries like ours. An irrigation dam, well designed but constructed with a poor distribution of water to the fields would be a very bad investment. An expensive piece of equipment, poorly maintained because skilled craftsmen were not available would be an equally bad investment. In both instances, an engineer would need to diversify his skills, in the first case to those of water management, in the second, day to day maintenance of machinery.

Isn't it our common experience here that substantial quantities of capital invested in such things as heavy earth-moving equipment, precision instruments used in the diagnosis and treatment of various kinds of illness, or even common consumer commodities like refrigerators, wireless equipment, hot-plates, etc., remain idle for long periods of time, or function defectively because of poor maintenance. It may be argued that such activities are for mechanics and skilled craftsmen and not for qualified engineers. But, surely the question at issue should not be who lays bricks and cements them, but how soon can we get the super structure complete. It would be futile, nay wasteful, if not criminal, to ask such questions as who ought to look after routine maintenance and designing and installation. In a community like ours, when due to a whole series of interlocking social and economic pressures, the education available does not produce the whole spectrum of skills required in our economy, greater versatility in our trained personnel becomes a most valuable national asset. We need also to review our conceptions of the dignity of labour.

Most important of all, of course, is that the country shall have all the engineers we need and in as many fields of specialisation as we can possibly manage. The National Council of Higher Education is most anxious that our Universities should maintain standards comparable to those of developed countries so that our manpower needs are supplied at the highest levels. With free education and science education rapidly being made available even in rural areas, there will be no dearth of first class material for higher education and research. What is necessary is the creation of opportunities for the fullest deployment of the talent and the skill which Ceylon fortunately possesses in such rich measure.

It is sad but nevertheless true that we yet have no really reliable statistics about the manpower needs of the country in spite of the many surveys that have been carried out. There does not seem to be sufficient liaison and understanding between planners, employers and employees. In the absence of such statistics Universities and other institutions of higher education are seriously handicapped with regard to the establishment of the necessary courses of training and the numbers to be admitted to them. We do not want, for instance, a situation to arise which seems to have occurred in India where there is a glut of unemployed engineers.

Such information as is available seem to indicate that the country needs immediately Maintenance and Construction Engineers, Management and Production Engineers, Design Engineers, Research Engineers and Engineering Teachers for each of the various branches of engineering—Civil, Electrical, Mechanical, Chemical, Marine, Mining, Geophysical, Nuclear and for their sub-divisions. Now that big projects like the Mahaveli Scheme and industrial undertakings like

the Petroleum Refinery have been initiated, the need for the training of personnel to man and implement them has become imperative. It must be remembered that while it takes a comparatively short time for instance, to put up a factory, it takes at least seven years to train a technologist. It has become increasingly clear that technical efficiency demands the employment of specialists for each component of a big project and it is the duty pre eminently of the Universities to provide them.

The sudden expansion of our Universities has created serious problems in staffing. Then there is the Brain Drain both from Universities to Corporations which offer temptingly large emoluments and to foreign lands where more amenities are available. Universities should not be academic ivory towers. They should undertake advanced studies in local projects and materials, carry out research into government projects when called upon to do so and even participate on certain terms in work and research for the private sector. For the expansion and streamlining of Universities to produce creative scientists and technologists and embark on applied research, funds are needed which our Universities do not have. They are desperately in need of funds even to enlarge existing faculties and equip them adequately. Some of them are not yet even full-fledged Universities.

Large scale industries and other development projects are being started and it is no secret that some of them are being managed by untrained personnel. If Universities are expected to meet the challenge of producing trained manpower they should be given the necessary funds to do so. When estimates are being prepared for a big project, provision should be included for the training of the personnel needed for such project and this provision should be made available to the Universities at the earliest opportunity. It is but reasonable to expect that where millions are being spent on some vast scheme, a modicum at least of the funds provided should be set apart to ensure that the project is being handled by people trained and capable of doing so successfully.

I have already taken too much of your time, but, with your permission, I wish to say one thing more before I sit down. Engineers should not only be pragmatists, they should also be visionaries. In a big sense they are the planners of the future. There is no need to remind ourselves that we live in most stirring times. Nature does sometimes make jumps, though rarely so, and we who are alive now are witnesses to one of these leaps. When such a leap occurs a new system emerges which is no longer understandable or predictable by the laws that governed the old one. The new youth which we find everywhere with their guitars and long hair, the hippies and the flower people, is probably symbolic of what the future has in store for us. A revolution is around the corner, if it has not arrived already,

and we cannot afford to be caught unawares. Cybernetics is with us, whether we like it or not and it presages changes in the social system so vast and so different from those to which we have been accustomed that it will challenge to their roots our current perceptives about the viability of our way of life. We all of us, to whatever section of humanity we may belong, therefore, need a new vision of life and of the universe. Our eastern religions and philosophies say that the universe lives in man. He has made of it many things: what he will do with it in the future, whether he will make a heaven of it or a hydrogen hell or something in between, will be a matter of his own making. We have talked too long of the conquest of Nature. It has not brought us either peace or happiness. What is necessary is not to conquer Nature but to understand Nature and to live in harmony with it, in accordance with what the Buddha described 25 centuries ago as *dhammanudhamma patipatti*. Let us talk less of the assertion of human power and more of the acceptance of human responsibility. Human solidarity, until recently a vague moral inspiration, has now become actual interdependence.

Some one has said that two great trends characterize our times. One is to mechanize humans, the other to humanize machines. If man uses machines, he carries on all the affairs of life like a machine. This produces a machine-heart in his breast, and he loses the simple virtues of love and compassion. If this process continues, the ultimate result will be for the two trends to cross—for the man-machine to be identical with the machine-man and, perhaps, at that point some one will give the machine man a soul. If this is not to happen, we must develop a new type of man who can restore the lost equilibrium between inner and outer reality. Science and technology are not enough.

You, as engineers, have a great chance of producing such a man, for your work, if it is performed with right understanding, is fundamentally a service to humanity, a work of great merit. We have in our ancient literature stories of men who became rulers in the realm of the gods by repairing a road, by building a simple bridge so that wayfarers may travel with less difficulty. Such is the true engineer who uses the resources of Nature for the benefit of man and May it always be thus.

I have great pleasure in declaring open this 63rd Annual Sessions of the Institution of Engineers, Ceylon, and to wish your deliberations every success.

THE INSTITUTION OF ENGINEERS, CEYLON

Presidential Address — 1969

by Mr. A. N. S. Kulasinghe, B.Sc. (Eng.) Hons. (Lond.), C.Eng., F.I.C.E., M.I.E. (India), F.I. Mech.E., F.I.E. (Cey.)
Port Commissioner and Chairman, State Engineering Corporation.

Dr. Malalasekera, Your Excellencies, Dr. Rowe and fellow members,

It is my privilege today, as President of the Institution, to speak to you on some thoughts which I have been having. This is a unique occasion which an Engineer gets, probably once in a life time, and therefore I have mentioned certain things which I may not have mentioned under normal circumstances. Since this is a unique occasion, certain things which I may say may also be considered unique.

The Presidential address normally is on a subject that the President himself has been concerned with for some time, and therefore I have chosen as my subject "Some Contributions to Engineering Development in Ceylon", to tell you some of the developments that have taken place after Independence in which our Engineers have taken part, especially the young members of the profession.

Engineering development in Ceylon has been quite significant during the last 20 years. Certain advancements have taken place in Engineering Science during this period in Ceylon which are quite significant when compared to what has been happening before, although these are not spectacular like the developments in more advanced countries in the world. The opportunity for this development has been created by the emphasis on development projects undertaken to improve the economic position of the country stimulated by the obtaining of political independence.

Prior to Independence, development works were geared to produce more revenue for the Colonial Powers, although a certain amount of importance was given to the improvement of the standards of living in the country itself. However, post-independence development works were completely removed from this objective and the total emphasis was on the progress of the country and its people.

A further change after Independence was that the responsibility for the proper execution of these development projects was transferred to the Ceylonese themselves though advised in most cases by Foreign Consultants and Advisors. The early project like the Gal Oya Development Works were completely designed and executed by Foreign Consultants and Contractors, with the local Engineers having some degree of control. Gradually this system has been changing with more and more responsibility being taken by the Ceylonese Engineers themselves, and now we find a situation where complete projects are conceived, designed and executed by the Ceylonese themselves, although some of them are still controlled by foreign agencies. This is due mainly to the lack of our own financial resources and the necessity for depending on finances from abroad and also due to the lack of confidence on the part of our own people in Ceylonese Engineers and Technologists who have proved themselves to be equal if not better than some of the Foreign Experts who come to advise us. This, I believe, is a lingering part of a situation developed during the long years of foreign domination. The position is made worse by the lack of awareness of modern development on the part of these in key positions of responsibility.

There have been cases where the local Engineers have been able to stand up to the vested interests from outside and deliver the goods. This should be a sufficient indication to the local powers that it is not essential for expert advice to come from abroad for success of projects. There have been many instances where such advice has been proved completely wrong. This has been revealed in a number of cases in Civil Engineering as well as in Industrial development. Whether such wrong advice had been motivated by vested interests or whether it was sheer ignorance on the part of these advisors, we are unable to say. There have been cases where we have been advised to close down industrial projects on the basis that they could not be run economically, but our local experts have provided the answer by converting these projects into successful ventures, when they were allowed to carry out the work unfettered by interference.

I have made these remarks above as an introduction to some of the developments which I wanted to deal with today. The above remarks serve as a background against which developments I have been connected with have been taking place. I have also decided to deal with those developments with which I have been associated as this is an area on which I can speak with some confidence and Presidential addresses are generally on subjects with which the President himself has been long associated.

The emphasis on the use of local talent for the execution of projects and the freedom given to local Engineers and Technologists to carry out the work without rigid control by superiors who were

interested only on the benefits accruing to a particular sector gave me also the opportunity of undertaking certain developments in Ceylon which were geared to solving some of our own problems.

My appointment as Assistant Harbour Engineer (Maritime) of the Colombo Port Commission in 1948 brought me face to face with the severe problem of the deterioration of maritime structures in the Port. It is well known that Colombo has some of the worst conditions that maritime structures can be subjected to in the way of corrosion. This has been indicated by a long series of tests carried out by the Institution of Civil Engineers in collaboration with various authorities round the world including the Colombo Port Commission. As a result of these very severe corrosive conditions the life of steel and reinforced concrete structures in the Port had been shortened considerably and therefore a solution to this problem had to be found as early as possible. The first solution was the use of gunite as a means of repairing reinforced concrete structures which had deteriorated due to corrosion. However, it was felt that this was only a temporary measure and that the problem would repeat itself. It was under these conditions that I considered very carefully the use of prestressed concrete for maritime structures due to the fact that it has a high degree of resistance against deterioration due to the virtual absence of cracks under normal working conditions.

At this time, that is in 1949, prestressed concrete was unknown in Ceylon and the amount of knowledge on this subject even in more advanced countries was quite small. However, I decided to learn the subject as I went along and produced a design for the re-decking of coaling jetties making use of a composite concrete slab made up of pretensioned inverted T sections with an "in situ" concrete to complete the composite construction. This design was completely successful and it proved to be so satisfactory that very little improvement has been made on this design during the last 20 years. It has also served as the basis of a number of further developments on similar lines. The span of the original pre-tensioned beams was 20 ft. and carried a live load of 450 lbs. per sq. ft. I am glad to say that much longer spans making use of this same principle have been achieved both in the port and outside. Considerable progress has been made by the Chief Engineer Bridges of the High Way Dept. in the use of this type of construction.

Along with the development in pre-tensioned concrete decks the manufacture of prestressed concrete railway sleepers and transmission line posts was also started. Here again, the information available on the design and performance was very meagre and their development had to depend entirely on our own resources and the risks we were prepared to take.

With the knowledge gained in the use of pre-tensioned prestressed concrete, bolder schemes were undertaken which required post-tensioning. At this time there were only a few post tensioning systems available in the world including the pioneer systems of Fresynet and Magnel. I considered the use of these systems and I opted to start on the Magnel Blaton System, as it was possible to manufacture the components for the anchorages and also the prestressing jacks for this system in our own workshops, whereas, the use of the Fresynet system involved the import of equipment as well as the consumable components. Work was started on some projects, the first being the construction of the bridge over the St. Sebastian Locks carrying the Mc Callum Road. This was executed using the Magnel system, while negotiations were under way for obtaining a licence for the use of this system in Ceylon. These negotiations broke down however, due to certain legal problems, thus creating the necessity for the development of our own system of post tensioning.

The principle that had been established for the Fresynet system in making use of the plastic flow of concrete to anchor the wires in the anchorage, made me think of using a comparatively soft material for my anchorages, although the practice at that time had been to use hard steel for these components. From experiments carried out based on these principles the system of post tensioning which is now known as the "Kulasinghe C.P.C. System" was developed in 1955 and used successfully on the post tensioned structures of the 100 ft. span warehouse at Lotus Road. Several new features were involved in this development the most important being the use of mild steel anchor blocks and wedges to anchor the wires. The basic post tensioning cable consists of 12 wires arranged in a particular fashion by the use of spacer grills and anchored in pairs in six tapered holes in the mild steel block using six mild steel wedges. The bearing pressure on the concrete was brought down to a safe value by the use of a distribution plate placed underneath the cylindrical anchor block. Some features of the post tensioning jack were also novel. The jack combined the three main operations of post tensioning. They are the tensioning of the wires, the driving of the wedges to anchor the wires and the release of the wires from the jack itself by the closing action of the jack. This was the first time that this last feature was included in a post tensioning jack, the method used in other systems being to drive the wedge out by a hammering process. These three operations are controlled from a manifold valve mounted on the hydraulic pressure pump which supplied the oil under pressure for the operation of the jack. Another feature of this jack was that it was built almost entirely of high tensile aluminium alloy with only certain parts in high tensile steel. This was also quite unusual for prestressing jacks at that time.

The development of this post-tensioning system enabled a large amount of post tensioned prestressed concrete projects to be carried

out without depending on foreign 'know how' or equipment and local Engineers who were associated with us in these developments were also gaining sufficient confidence to carry out design and construction on their own. I am happy to mention here that some of the enthusiastic young men who were engaged with me during the early days have been able to carry this knowledge to other places and help in the development of 'know how' in places outside the port.

I would like to mention here some of the major projects that were carried out using this system. The 120 ft. span roof structure of the National Textile Corporation Textile Mill at Veyangoda was carried out using this system in the last 1950s. The 127 ft. span roof beams of the Food Warehouses at McCallum Road are so far the longest span roof structures in Ceylon.

The knowledge gained in the practice of prestressed concrete enabled further developments to take place. One of the early developments which came out in this way was the system of piling and cylinder sinking making use of prestressed concrete components. My responsibility in the construction of jetties in the Colombo Harbour and the difficulties met with in such projects, where conventional methods were used led to the development of a method of construction and sinking prestressed concrete cylinders in maritime structures. The principle of the method was to precast thin cylinders of about 6 ft. dia. 4" thick and 4 ft. high which were joined together by post tensioning cables using a 4 wire cable and anchorages which had been developed. The initial length of cylinder which was determined by the depth of water at the site was obtained by joining sufficient 4 ft. sections to give the required length, with a special cylinder at the bottom which had a steel cutting edge built into it. The process of handling this cylinder and sinking it has been described elsewhere. The Research Committee of the Institution of Civil Engineers has concluded that this was a pioneer development in this field.

This system of cylinder construction which used a cylinder grab for the excavation of material inside the cylinder has been later developed for use with an air lift percussion cutter which has improved the speed of construction considerably. An important feature of this system of cylinder construction is the use of a 15 ton hammer which has an annular cross section providing a hollow in the centre of 5 ft. 4 in. dia. which is the same as the inside diameter of the 6 ft. cylindrical pile. Thus the excavation in the cylinder can be carried out through the hammer while the hammer drives the cylinder down. The same principle has been made use of in smaller dia. piles viz., 18" external dia. and 12" internal dia. making use of a 5 ton hammer for driving and a percussion air lift for excavation. This method of excavation was developed around 1955 and it is now widely used in this field and is known as the Reversed Circulation Process of drilling.

Most of the maritime construction in the Port has made use of these two systems of piling. A number of structures outside have also been founded on these piles. The speed of operation using the air lift percussion system was demonstrated effectively when it was possible to increase the speed of Benoto piles nearly four times when the usual hammer grab was replaced by the "air lift percussion rig."

The know-how available in pre tensioned concrete and post-tensioning gave the opportunity of another development. Here I refer to the use of the thin concrete shells for covering large areas.

The experience in Ceylon of concrete flat roofs had been generally unsatisfactory due to the climatic conditions to which these roofs are exposed, and therefore, work was carried out in developing some form of thin shells to suit local conditions. The forces in a shell are carried mainly by membrane forces, generally in compression. This helps in maintaining a shell comparatively crack free which is one of the main requirements for durability in a hot and wet country like ours. The time when we started work on shell construction, people who had some knowledge on this subject kept this mostly to themselves and as a result the use of shells did not develop as fast as it should have done. However, we were not afraid to take risk in trying out some forms of shell construction. Work was started on the development of a system of constructing cylindrical shell roofs using precast elements prestressed together. It is well known that the shuttering in a cylindrical shell forms the major part of the cost of the shell and any method of avoiding such shuttering contributed towards the economics of shell construction. Finally, a system of pre-casting of cylindrical shells was worked out and the first shell constructed was a 50 ft. span and 20 ft. wide shell to house the Structures and Concrete Laboratory of the Port Commission. The method of constructing these shells was as follows:

Precast segments of the shell which were about 3 ft. - 1 ft. were assembled between two edge beams making use of pre-stressing cables through the segments and prestressing them on the two edge beams. Ties were used to keep the edge beams from spreading apart. After the entire cylindrical surface was generated in this way precast traverses were erected and horizontal cables passed through the shell and anchored on these traverses. Thereafter, the main cables in the edge beams were stressed at the same time releasing the ties between the edge beams. Subsequently the shells were jacked up with a jack at each corner and the columns built underneath. This resulted in a cheap, durable and water proof shell. This same principle has been used in constructing larger shells in the Galle Harbour. They are 100 ft. span and 33 ft. wide three complete shells being built at ground level using this process giving an area of 100 ft. square and jacked up to a height of 20 ft. to form the roof of the warehouse. Four such combinations have a column free warehouse of 100 ft. x 400 ft. long.

From prestressed concrete precast shells the next development was umbrella hyperbolic paraboloid shells which were constructed in the late 1950s. The first such structure was the roof of the car part opposite the Colombo Port Commission Office which consisted of three umbrella shells of 40 ft. x 30 ft. The novel feature in this shell was the use of prestressed edge beams. Pre stressing of these edge beams was carried out to correct as far as possible the boundary conditions which gave rise to bending action in the shell. However, a more important problem was solved by this process and that was the correction of the corner droop of the shell. Work done by Professor Lyn on this subject about the same time indicated that corner droop could be corrected by edge pre-stressing in umbrella type Hyperbolic Paraboloid roofs.

Another development in shell construction was the evolution of a method of precasting long saddle shaped Hyperbolic Paraboloid shells on the long line of pre-stressing. Shells of similar shape had been precast by Silberkuhl in Germany, but he used a hyperboloid of revolution and they were cast in stack fashion.

The casting in stack fashion brought in certain problems of surface finish due to the top of one shell forming the shutter for the bottom of the shell above. My efforts were therefore to produce a shell which had a good finish on the soffit and produced in the long line of prestressing where several shells could be cast on the same line. A complete description of this process has been given elsewhere. It has enabled thin shells to be pre-cast and produced in a factory at a very cheap price with a steel content in the structure which was extremely small compared to other forms of shell construction. Several structures have been built using this method, the latest being the Workshop of the State Engineering Corporation at Peliyagoda. The first structure built was the Hydraulic Laboratory for the Port Commission with a column free area of 100 ft. x 100 ft. which was achieved by suspending 40 ft. span shells from parabolic arches which were best suited to support a uniformally distributed load. These shells do not require water proofing treatment which reinforced concrete shells generally require. They are also cheap compared with other forms of shell construction and compared even with the pitched roof using asbestos cement corrugated roof sheeting.

The biggest contribution to Engineering development in Ceylon was the setting up of the State Engineering Corporation in January 1962. There had been a long felt need for a construction organisation with the necessary know-how and the equipment to undertake large engineering projects which were beyond the scope of the local contractors. The setting up of this organisation was urgently needed for the construction of two large industrial projects for which no local contractors were available. These projects were the Steel Rolling

Mill at Oruwela and the Tyre Factory at Kelaniya, both of which were projects to be carried out on Aid from the Soviet Union. According to the agreement the technological equipment for these two projects and the design for them were supplied by the Soviet authorities. In addition to these services, they supplied the necessary building material like cement and steel and part of the construction equipment necessary for executing the projects. The cost of the Steel Rolling Mill was estimated at approx. Rs. 100,000,000/- and the Tyre Factory at approx. Rs. 60,000,000/-. At the time the State Engineering Corporation was established, the staff available consisted of only 5 Engineers, but very soon the man power and equipment were built up to handle these two large projects within the time limit set for their completion. The initial authorised capital for the Corporation was Rs. 1,000,000/- but no contribution was made towards this capital at that time and the work had to be started with a loan of Rs. 150,000/- from the two projects mentioned above and with arrangements made with the Industries Department to pay the salaries of the staff transferred from that Dept. from its own votes till such time as funds were available to the Corporation. With these arrangements it was possible to get under way an Organisation which had grown to a position capable of handling the biggest projects being carried out in the country and employing a staff of approx. 130 Engineers and a total labour force of approx. 13,000 men. The annual turnover has reached nearly Rs. 120,000,000/-. All this progress has been achieved within a period of less than 8 years.

The present rate of industrial development, especially in the Public Sector, could not have been achieved without the establishment of an organisation like the State Engineering Corporation. The presence of this organisation has enabled a large number of projects to be undertaken. At the same time the order book of the Corporation now stands at nearly Rs. 400,000,000/- with an annual turnover of approx. Rs. 120,000,000/- The undertaking of all these projects has stimulated the expansion of the State Engineering Corporation itself. It continues to expand even now. The projects being handled vary from large industrial Projects like (i) The Textile Factory at Thulhiriya costing approx. Rs. 200,000,000/- and (ii) the Harbour Development Project like that of Kankesanturai at a cost of approx. Rs. 25,000,000/- A large number of smaller jobs are also being undertaken, including hospitals, Technical Colleges and smaller Industrial projects.

The opportunity for executing such a large amount of work including the Mechanical and Electrical engineering aspects of these projects has enabled a Research and Development Department also to be established for carrying out research and development on problems connected with such projects as well as general problems connected with the Civil and Mechanical Engineering Industries in the country.

In the Civil Engineering field, the Research and Development carried out has been able to produce new building materials and new types of structures, particularly applicable to the conditions prevailing in Ceylon. Research has been directed mainly to the development of local substitutes for imported materials and the development of new materials based mainly on local raw materials and agricultural products. Considerable attention has been given to the development of clay products to replace asbestos cement products and concrete products while at the same time making better use of concrete products by improving the quality of the concrete and improvements in the design of the structural components and complete structures. In the field of clay products, it has been possible to develop roof purlins using clay units prestressed together. These purlins are very economical and durable, the cost being approximately half that of an equivalent purlin in timber.

A substitute has also been found for the asbestos roofing sheet which has a high content of foreign exchange for its manufacture. It is well known that the entire quantity of asbestos fibre used in this product has to be imported and approximately half the cement consumed in the country has also to be imported. It is, therefore, apparent that the foreign exchange component in asbestos cement products can be very high. A clay roofing tile which spans 4 ft. between purlins like the asbestos cement sheets has been produced. The foreign exchange component of this product is extremely small being only the cost of the small wires which are used for prestressing or reinforcing the tile to enable it to carry the prescribed loading for roofs. Being a fired clay product it is also very durable and the thermal insulation properties of this material are far superior to the other roofing materials used in this country. The cost is also much lower and the machinery required for its production is less expensive than those required for the production of asbestos cement sheets or even "Mangalore pattern" roofing tiles. It combines the insulation properties and durability of clay tilling with the economy in structural members provided by asbestos cement sheeting.

Another product of Civil Engineering Research is the 'Kohu Tex' insulating and roofing sheets which can replace ceiling sheets which are made of asbestos cement and also insulation material like glass fibre or expanded polystryince used for the insulation of air conditioned areas. In the Thulhiriya Factory alone, the saving in foreign exchange is over Rs. 3,000,000/- by using this material in place of glass wool insulation which was specified for the ceiling. Approximately 1,000,000 sq. ft. have to be produced for this factory.

Development work is being carried out to find more uses for this material which is manufactured from the waste products from the manufacture of coconut fibre and popularly known in Sinhala as

'Kohu bath'. In some of these products cement is used as the binder, but in some others the natural bonding quality of the material is mobilised for this process.

Research and development in the Mechanical and Electrical engineering also have been pursued with encouraging results. The work on the manufacture of large dredging pumps using natural rubber for the wearing parts has been quite successful and there are a number of such pumps of approx. 700 H.P. working satisfactorily. These pumps have been able to cut down the expenditure, especially in foreign exchange, involved in the maintenance of pumps made of abrasion resistant steel. It was our experience that while dredging in the Kelani Ganga for obtaining material for filling the marsh for construction of the Colombo North approaches through Peliyagoda, the material was so abrasive that a manganese steel volute case wore off in a week and had to be re-built involving an expenditure of approx. Rs. 10,000/- of which Rs. 8,000/- was in foreign exchange. The successful use of rubber for the construction of these pumps had enabled the life of a set of rubber wearing parts to extend to approx. six weeks, with the re-building cost of these parts down to a few hundred rupees. It has, therefore, been possible to achieve a lower cost and a much smaller time spent in the re-building work of these pumps.

Further development is continuing in the use of rubber for the manufacture of a variety of pumps, from sewerage pumps which have already been produced to small domestic pumps which are being developed. The emphasis has been on the use of rubber as a material of construction for the Engineering Industries as it is a local material with very good qualities which make it highly suitable for use in a number of applications.

Work has also been carried out in the manufacture of machine tools making use of concrete as a substitute for certain parts made of steel and cast iron in these machines. Hydraulic Presses of 100 ton capacity have already been produced using a frame in pre-stressed concrete. A morticing machine has also been produced using a concrete frame in place of the steel or cast iron frame which is normally used. This is a very interesting and fruitful field of development as the facilities required for producing and machining large castings or steel fabrications are not available in Ceylon. The use of concrete frames which can be moulded to the correct shape to accommodate steel or cast iron wearing parts located in them has enabled machines which would have otherwise been impossible to be produced in Ceylon to be manufactured for our use.

Considerable development has been made in the use of pre cast and pre-stressed concrete standard components in the construction of large Industrial Projects. The speed that has been achieved in their

execution has been mainly due to the techniques that have been used for the production of these components under factory conditions. By standardising these components it has been possible to produce a variety of industrial structures making use of a few types of components.

The know how that has been developed in their manufacture and erection has enabled such structures to be constructed both economically and expeditiously, enabling the commissioning of large Industrial Projects in a much shorter time than would have been possible by other means.

It has also been possible to establish a manufacturing plant for the production of pre cast units for the construction of multi-storeyed flats.The entire components for these flats are produced in the factory and it was possible for the construction of the flats to reach a peak of four a day. Further developments in this field have enabled the use of local material like extruded hollow clay products for the construction of wall panels, so that it has reduced the foreign exchange component and improved the appearance, durability and the thermal insulation of these wall panels. The factory that was set up at Narahenpita for the production of components for the flats at the Anderson Golf Links has a capacity of one thousand flats per year. It is a credit for our local engineers that this entire factory was designed and built in Ceylon without any foreign assistance and with only a few pieces of equipment from abroad.

Apart from the contribution to the development of engineering mentioned above, I must mention the most important results of these development, I refer here to the acquisition of a considerable amount of engineering knowledge by a set of young men, who have now gained sufficient experience in the engineering fieid to tackle with confidence any project that is likely to come up in Ceylon. They have gained the experience from small beginnings in a number of large and complex projects, so that there is not likely to be a project in the future where this experience will not enable them to execute such projects without the necessity of foreign advise or supervision.

Manpower is the most valuable asset of any country and the development of the technical skills of this man power available is, I think, the biggest contribution that any one can make to the development of a country which is in the process of getting out of a position which had been created by years of inactivity.

I have dealt at length with a number of developments with which I have been closely associated in spite of the risks of appearing to be immodest, because I felt that it is necessary to indicate to the profession as a whole and the general public the potential of our technologists and the possibilities of achieving progress by the proper

mobilisation of their talents. I like to draw attention to here to the lack of appreciation of this possibility in certain quarters which are responsible for the destiny of this country. Too much reliance is still being made on experts from abroad, some of whom cannot divest themselves of certain interests which may not be in complete sympathy with our interests.

Mistakes can be made by our own people in the initial stages of development, but these mistakes will be the foundation for a development, which later on we would be able to look upon with pride. It is better to make mistakes and learn to do things ourselves than to rely on outsiders all the time for our guidance. I therefore, plead with those in power to let our own people handle some of the things that are now being handed over to outsiders, because there is sufficient evidence produced in this country already that our people are capable of carrying out these tasks. The fact that we are Ceylonese and the tasks ahead are for the benefit of Ceylonese should be a guiding factor for for the success of such undertakings.

THE INSTITUTION OF ENGINEERS, CEYLON

Supplement to the Presidential Address

CEYLON GOVERNMENT RAILWAY

Mechanical Engineering

One of the eight Shunting Locomotives that are being built locally is being assembled in the workshops. This locomotive will be put out in the very near future.

The only Kitchen Car in the Railway is being remodelled and is being equipped with deep freezers, bottle coolers and hot plates worked by 3 K.V. generator plant to improve the existing catering services.

The complete dieselisation is being implemented with the arrival of 87 Diesel Hydraulic Locomotives. The re-organisation of the workshops in keeping with the requirements of the dieselisation had to be effected for smooth working and maintenance. The entire group of steam locomotive repair shops has been re-organised to handle Diesel Locomotives.

A start has been made to build aluminium bodied coaches on 2 steel underframes and the prototype aluminium bodied coaches are expected to be completed this financial year.

Consequent to dieselisation and scrapping of steam locomotives a large number of imported spares for diesel locomotives are now being manufactured in the workshops. During the year over 100 such items have been produced locally.

Track Maintenance

The total number of sleepers supplied by the State Timber Corporation has been 818,217 Broad Gauge sleepers and 7452 Narrow Gauge sleepers. The total number of sleepers used for re-sleepering being 96,654 Broad Gauge sleepers and 10,417 Narrow Gauge sleepers. The excess over the supply had been used from the previously imported stock available, namely, the Malaysian sleepers. During the period 9m. 4c. of 80 lbs and 9m. 77c. of 88 lbs. rails were used on re-railing the track. As far as practicable most of the speed restrictions due to weak track materials have been removed.

New Central Station Building at Colombo Fort

Pile driving for the construction of a modern Terminal Building is in progress. This Station will have six additional platforms to serve long distance traffic. With the construction of this Station the suburban traffic will be exclusively dealt with on the Olcott Mawatha side.

New Diesel Shed

A new Diesel Shed is nearly complete at Lazerratto where running repairs will be carried out to the present diesel locomotives and the new diesel locomotives which have arrived and are arriving in the Island.

Extension of the Railway line from Bangadeniya to Puttalam

The re-construction of the Railway Line from Bangadeniya to Puttalam is completed except for the quarters, which items are in hand.

Extension of the Railway line from Puttalam to Illavankulam Clay Fields, Aruakalu Branch to Lime Stone Quarry and Branch Line Stone Quarry and Branch Line from Palavi to the Cement Factory at Attavilla

The laying of the Railway line from Puttalam to Illavankulam and Aruakalu has been completed. Only the work on the construction of the sub-structure of a number of major bridges spanning the waterways of this line remains to be done along with track ballasting making up cesses and embankments and providing earth drains etc. and building of stations, halts and quarters for Staff.

Signalling

The materials ordered on indent required for the extension of the Colour Light signalling from Ja-Ela to Negombo on the Puttalam line and from Veyangoda to Polgahawela are being received and work will be continued.

PUBLIC HEALTH ENGINEERING DIVISION OF THE DEPARTMENT OF HEALTH

This Division is responsible for the Design and Construction of all Water Supply, Sewerage and Surface Drainage Schemes to Medical Institutions.

Completed

1. Galle Hospital Water Supply Scheme Stages I & II consisting of a 50,000 Gal. R. C. Water Tower, 6" Cast Iron pumping main, 3 wells, submersible pumps and chlorinators. The cost of these two stages was Rs. 500,000/-.

Stage III of the scheme will be relaying of the distribution system with PVC at a cost of Rs. 150,000/-. This will be undertaken this financial year.

2. Nikaweratiya Hospital Water Supply Scheme costing Rs. 400,000/-. This scheme is designed to obtain raw water from Magalla Tank and after chemical dosing, filtration and chlorination, water is pumped into a 20,000 gal. R. C. overhead water tank.

Under construction

1. Badulla Hospital Sewerage Scheme, the cost of which is approximately Rs. 1 million. This scheme consists of a complete treatment plant of the high rate bio-filtration with sludge digestion and drying beds. After the effluent is finally chlorinated it discharges into a water channel which thereaafter discharges into the river.

2. Wathupitiwela Hospital Sewerage Scheme costing approx. Rs. 750,000/-. This scheme is also the same as at Badulla.

3. Alutnuwara Hospital Sewerage Scheme costing approx. Rs. 600,000/- was designed by this Division but is being constructed by the State Engineering Corporation. The process of treatment is the same as that for Badulla and Wathupitiwela.

4. New KKS Hospital Sewerage Scheme. The cost of this scheme is Rs. 700,000/- and presently under construction by the Colombo Commercial (Engineers) Co. Ltd. This scheme has an activated sludge plant having the Simplex Surface Aeration system with sludge digestion and drying beds.

CEYLON ELECTRICITY BOARD

With the establishment of the Ceylon Electricity Board under the Ceylon Electricity Board Act No. 17 of 1969, and subsequent order made by the Hon'ble Minister of Land, Irrigation & Power, the former Department of Government Electrical Undertakings has now been vested in the Ceylon Electricity Board with effect from 1-11-69. With the change over the functions of the C. E. B. would be more flexible and it would bring in more efficient co-ordination of the generation, transmission, distribution and retailing of electricity right throughout the Island as the C. E. B. would be a central authority.

Maskeliya Oya Project, Stage I

The 75 Megawatt, Hydro Power Station at Polpitiya under Stage I of this Project was commissioned during March 1969.

Maskeliya Oya Transmission Lines Project

This project involves the construction of 303 miles of 132 kV. transmission lines, 525 miles of 33 kV. distribution lines and 8 Grid Substations. The survey works have been completed and erection of towers and stringing are in progress. Works on the Sapugaskande and Thulhiriya Grid Substations are almost completed while works on Deniyaya, Habarana and Anuradhapura Substations are in progress. About 30% of this project is completed.

Rural Electrification Project

A good portion of materials have been received and about 80 schemes have been completed while work on about 200 schemes are in progress. 30% of work on this project is completed.

RIVER VALLEYS DEVELOPMENT BOARD

Uda Walawe Multi-Purpose Reservoir Project

The construction of the Uda Walawe Reservoir was completed during the year under review. The live storage capacity at the reservoir is 203,500 acre-feet with a F.S.L. of 290 M.S.L. and a draw down of 50'. The water released from this reservoir will irrigate an area of 28,000 acres of new land in the Right Bank and 50,000 acres of new land in the Left Bank. It will in addition supplement the irrigation requirements for 12,500 acres of existing paddy fields below Liyangahatota Anicut and another 5,300 acres under Chandrikawewa Scheme. The Head Works constructed at a total cost of Rs. 59,000,000/- incorporated the following major structures:

(*a*) R. B. Irrigation outlet designed to discharge 650' cusecs together with a Kaplan type Turbine with an installed capacity of 1.8 megawatts.

(*b*) L. B. Irrigation outlet designed to discharge 1000 cusecs with 2 power plants of Kaplan type each with an installed capacity of 1.8 megawatts.

(*c*) A Radial Gated Spillway of total length 310'. This is designed to discharge 174,000 cusecs of excess inflow; from the reservoir during floods. The Spillway has 5 Radial Gates each 62' wide x 20 high. This being the biggest Radial Gated Spillway so far constructed in Ceylon.

(*d*) The formation of a 1,250' long natural spillway. The designed discharge is 83,000 cusecs.

A major structure which was commenced and completed during the year is a reinforced concrete syphon under-crossing with a barrel

diameter of 12 feet and a total length of 1050'. This syphon will carry the L. B. Main Canal which has a capacity of 1000 cusecs below and Spill Tail Channel of the Walawe Reservoir. The cost of this structure is Rs. 2 million.

Besides the Head Works, about 22 miles of main channel on R. B. and another 7 miles of Main Canal in the L. B. were completed. An area of about 4,000 acres were made ready for irrigation for the first time for the ensuing Maha (1968/69) both on the R. B. and L. B.

Work was commenced on the construction of a Brick and Tile Factory close to Embilipitiya at an estimated cost of Rs. 3,200,000/-. Installation of the machinery is now in progress. The factory will have a capacity to manufacture 5 million bricks and 3 million tiles per year.

A reinforced concrete aqueduct 274' long and 18' wide is under construction across Mau Ara. This will carry the L. B. Channel conveying about 1,000 cusecs over the Mau Ara River.

Gal Oya

Provision of irrigation facilities to 14,000 acres of Manawari lands from the Senanayake Samudra is in progress. This will complete the provision of irrigation facilities to the 120,000 acres originally proposed under the Senanayake Samudra Scheme.

Heavy Construction Division

The River Valleys Development Board also established a Heavy Construction Division in order to utilise its resources for the speedy construction of major buildings, earthwork etc. for other Government Departments. Some of the major works undertaken by the H. C. D. out-side the project areas are:

Completed:

(*a*) Construction of the Nagadeepa Reservoir.

In Progress:

(*b*) Construction of Muruthuwela Reservoir
(*c*) Construction of Ella-Wellawaya Road
(*d*) Construction of New Hospital, Kahatagasdigiliya
(*e*) Construction of New Laboratory and Hostel Building, Agricultural Research Station, Maha Illuppallama
(*f*) Construction of the earthwork for the Railway Track Extension for the Cement Works, Puttalam.

CEYLON CEMENT CORPORATION

The Ceylon Cement Corporation is at present engaged in an expansion project with a view to increasing the production of cement

from 80,000 tons in 1962 to 720,000 tons in 1972. The recent trends in the production and consumption of cement and the present position is as follows:—

Year	Total Consumption Tons	Local Production Tons	Percentage of consumption met from local production
1966	337,900	81,572	24.1%
1967	373,000	188,741	50.5%
1968	413,000	217,000	52.5%
1969	500,000 (Estimated)	250,000 (Estimated)	50.0%
1970	550,000 (Estimated)	430,000 (Estimated)	78.0%

Kankesan Cement Works

The 3rd Cement Mill with a capacity for grinding 100,000 tons of clinker has also been installed and is due to be commissioned in December 1969. The entire cost of this item inclusive of civil works is Rs. 2.3 million.

Puttalam Cement Works—Stage I

Construction work in respect of Stage I Complementary Civil Engineering Works is about 95% complete and about the same percentage of machinery has been erected. It is expected that by the end of November 1969, all civil engineering and mechanical erection work will be complete. The plant is due to be commissioned in the following months. The revised estimate providing for FEECs. etc., for this project is Rs. 94.5 million and the expenditure incurred upto 30th September 1969 is Rs. 75 million. The plant has an annual capacity of 220,000 tons.

The machinery for Stage I has been supplied by Messrs. Klockner-Humboldt-Deutz. The Civil Engineering Works was undertaken by the State Engineering Corporation and machinery erection by the Ceylon Cement Corporation.

Puttalam Cement Works—Stage II

Puttalam Stage II envisages a further increase in production by 220,000 tons. During the year under review, certain parts of civil engineering work required for the integration of Stages I & II have been undertaken and completed by the State Engineering Corporation. The Contract for the supply of machinery in respect of this contract was signed with the same plant suppliers on 28th July, 1968, and all works in respect of Stage II is expected to be completed by September 1971.

CEYLON CEREMICS CORPORATION

New Projects—Year Ended—30th September, 1969

	Works Completed	Works in Progress	Works scheduled for after 30.9.69	
Electrical Porcelain Project				
Civil Engineering Works				
Site Clearance	10,000			
Construction of access Roads, Factory Buildings, Construction of Drains, Construction of Toilets		530,000		Works Entrusted to the State Engineering Corporation of Ceylon
Kiln Foundation			75,000	
Electricity Supply & Installation Switch Boards, Sub Boards, Wiring Motors & Electrical Lighting & Underground Cables			158,000	
Plant & Machinery			1,200,000	
Testing Equipment			155,000	
Erection of Machinery			240,000	
Foreign Erection Personnel			360,000	
Furniture & Fittings			60,000	
Contingencies			112,000	
	10,000	530,000	2,360,000	

SURVEYOR GENERAL'S DEPARTMENT

The following Major Engineering Surveys were supplied to the Customer Departments:—

	Acres
Pallekelle Estate—(Phase I & II) ..	4,100
Silavaturai	5,280
Malwatu Oya in Aruvi Aru Basin ..	13,340
Pimburettewa	6,700
Inginimitiya	5,280
Maha Oya, Gin Oya, Thoduwewa ..	8,000
Heda Oya in Karanda Oya Basin ..	24,960
Samanalawewa	27,740

Muthuaiyankaddukulam Block 'B' ..	5,000
Koggala Lake Drainage Scheme ..	10,875
Nilwala Ganga Basin	24,101
Galodi Aru and Maha Oya (Reconnaissance Survey)	16,000
Rambukkan Oya (Reconnaissance Survey)	8,515
Deduru Oya Reservoir (Reconnaissance Survey)	87,800
Sengal Oya	41,800

In addition to the above, prints of 43,072 acres of other Engineering surveys, 22,095 acres of Village Tank Surveys and Tracings of 329 miles of Channel Trace Surveys were supplied.

Field and Planwork of the following Engineering Surveys have been completed and plans are under reproduction.

	Acres
Giants Tank Irrigation Area	58,000
Akkathimurippu Irrigation	15,200
Hikkaduwa Ganga S. W. E.	8,268
Kaluwamodara S. W. E...	5,250
Kalu Ganga Basin	36,700
Gin Ganga Basin	40,383

The following surveys were done in connection with MAHAWELI PROJECT and plans supplied:—

	Acres
Kalawewa—Kandalama L. B. & R. B.	12,480
Kalawewa R. B.—16 Chain Reconnaissance	52,000
Victoria Power House	500

Field work of the following surveys were completed and plan work is in progress:—

	Acres
Deduru Oya Reservoir	39,020
Inginimitiya	11,360
Sengal Oya	8,040
Uda Walawe Block 'A'	8,220
Lunuganwehera Reservoir	9,000
Heda Oya in Karanda Oya Basin ..	14,360
Watawala Kandiya	6,040
Giants Tank Extension	8,000

In addition to the above 8490 acres of other Engineering Surveys, 17,900 acres of Village Tank Surveys and 376 miles of Channel Tracing were completed.

Field work of the following surveys for 'MAHAWELI PROJECT' have been completed and plan work is in progress:—

	Acres
Kalawewa LB	30,000
Kalawewa RB (Extension)	38,000
Kalawewa RB	40,000
Kandalama LB & RB	9,760

INDUSTRIAL ESTATES CORPORATION

The construction and development of the Regional Industrial Estates in Kandy, Galle and Jaffna were planned by the Corporation during this period. Preliminary works regarding these schemes has been completed and at Pallekelle in Kandy, construction work commenced in late August this year. Construction work in the other two Estates, Boossa in Galle and Achchuvely in Jaffna are scheduled to commence in November this year.

CEYLON PLYWOODS CORPORATION

In the year under review a land mark in the progress of the Ceylon Plywood Corporation was achieved with commissioning of Civil Engineering Works by the State Engineering Corporation on our behalf for the Second Plywood Factory & Integrated Woodworking Complex to be set up in Kosgama. This project from both magnitude and complexity and the integration of the four principal manufacturing units such as plywood, sawn timber, chipboard and furniture is the first of its kind in the whole of Asia. Machinery and technical assistance are being provided under the contracts signed last year to be financed under the Czechoslovakian and Rumanian Lines of Credit. Self-sufficiency in tea chests will be achieved with the commissioning of the plant in 1971 resulting in a saving of Rs. 20 million per year in Foreign Exchange.

Export activities of the Corporation will be stepped-up with the increased output of commercial and decorative grade plywood, flush doors, veneer, veneered chipboard, sawn timber and furniture. Furniture of high class will be produced from the fully mechanised manufacturing and finishing line scheduled for commissioning in 1971 with the rest of the items of the Complex, except the Chipboard Factory which is scheduled for commissioning in April 1970.

CEYLON STATE FLOUR MILLING CORPORATION

Name of Project : Ceylon State Flour Milling Corporation. Construction of Flour Mill with the aid given by the Government of U.S.S.R.

Installed at : Mutwal

Year of Production commenced in December 1968.

Landed cost of machinery	:	Rs. 8.2 Million
Cost of erection of the Machinery	:	Rs. 6.0 Million
Cost of buildings including Steel & Cement supplied by the Corporation		Rs. 11.9 Million.

THE INSTITUTION OF ENGINEERS, CEYLON

Vote of Thanks

by Mr. A. MacNeil Wilson
Vice-President

Mr. President, Your Excellencies, Distinguished Visitors and Colleagues. We have heard today two speeches by two men, each eminent in his own field. My task is to propose a vote of thanks to our chief guest, Dr. Malalasekera, while, I am afraid, our President who has done a magnificent job of work, does not even get thanked at this stage.

There is no doubt from what Dr. Malalasekera has said that in the society which exists today and in the society which exists on our horizon, engineers of all disciplines and categories are going to be called upon to play a role which is ever increasing in importance. For this very reason, the Council of Engineering Institutions in Britain has introduced into the syllabus a subject called "The Engineer in Society". When we had our Sessions last year, the Hon. Minister of State, Mr. J. R. Jayawardena, touched on this point and our President in his vote of thanks stressed the willingness of the members of this Institution to give of our knowledge and our experience in the development of Ceylon.

Today we have as our Chief Guest a most distinguished scholar and I wonder if any of you realised when listening to Dr. Malalasekera, that on 9th of next month he will have reached his three score years and ten? and what a packed and diverse seventy years he has had. He has set an example which I think it would be wise for all engineers to follow.

Dr. Malalasekera's father, an eminent Ayurvedic Physician, hoped that his son might become a doctor who would pioneer a fusion of the Eastern and Western systems of medicines. This might well have happened if it had not been for the fact that during his 3 years at Medical College young Malalasekera, while studying Physics, Chemistry, Biology, Anatomy and Physiology, also studied for his B.A. which he successfully completed at the ripe old age of 19. Later at the School of Oriental Studies at London University he passed his M.A. with distinction and was awarded his Ph.D. for his Thesis on Pali Literature in Ceylon. This incidentally was published by the Royal Asiatic Society of Great Britain in their Prize Publication Series.

His primary interest then became education and in 1927 he joined the Ceylon University College, later the University of Ceylon, heading the Department of Oriental Studies until he was selected as Ceylon's first Ambassador to the Soviet Union in 1957. As we all know, he is now Chairman to the National Council of Higher Education.

What do you think, gentlemen, has made this success story a reality? Apart from hard work, because he once said that you could always get more work done by sleeping an hour less, surely it was the breadth of his knowledge, the wide span of his vision, the broad base of his thinking which has not been hindered or hampered by narrow confined fields.

A year ago it might have been felt that the voices of members of this Institution were not heard but during the last year due to the efforts of our President great strides have been made. Engineers from both the Public and Private Sectors have been called to meetings by the Honourable Prime Minister and we have reason to believe that in the future there will be more discussions of this type.

We must be prepared and it is I think, therefore, particularly apposite that we should have had the honour of some one of Dr. Malalasekera's calibre and wide vision to open our sessions today. I am sure that by following his example and widening our own view point we can more effectively give of our service in the interest of this country as a whole.

On behalf of the Institution of Engineers, Ceylon, I thank you Sir, for having so graciously inaugurated the Sixty Third Sessions of the Institution.

THE INSTITUTION OF ENGINEERS, CEYLON

President's Introduction of the Guest Speaker

Gentlemen, I think you are all waiting to listen to Dr. Rowe's lecture but before I invite him to deliver his lecture, I would like to briefly tell you so many things that I should have mentioned this morning.

Dr. Rowe graduated from the University of Cambridge in Mechanical Engineering Science and after graduation he joined the Cement and Concrete Association in the Research and Development Division. This was at that time headed by Dr. Maurice who is now Professor of Civil Engineering at Southampton. Dr. Rowe after joining the research and development section of the Cement and Concrete Association was actively engaged in research, into problems connected with reinforced concrete bridges and the ultimate strength design of bridgedecks. He became head of the research department in 1958 and developed the application of model testing of design. I am sure most of the engineers familiar with concrete structures know the contributions that Dr. Rowe has made to design procedures and model analysis. You will also remember the work he had done on "Micro concrete" and its application to the construction of Models. I know the model studies that he did of the bridge in Manchester—the "Mancunian Way"—which is one of the outstanding examples of concrete construction in England. It consists of a very bold type of bridge and Dr. Rowe carried out all the model investigations because there were complicated problems. I have seen the work on this and I am sure he can be acclaimed an expert on this subject. In 1962 he published a book on Concrete bridge design. Every bridge designer who uses concrete is familiar with this and the design charts which he produced makes work quite easy.

In 1966 he became Director of Research and Development of the Cement and Concrete Association. You all know the contribution that the Cement and Concrete Association of England is making to the Advancement of knowledge on concrete as a material and concrete structures generally; and you will be pleased to note that Dr. Rowe has been behind most of this work, especially on the structural side. Over the last four years, he had been actively engaged in the drafting of the Unified Code of Practice in the structural use of concrete. As you know, there are 3 codes for dealing with concrete in various structures. I do not wish to keep you waiting any longer; I have great pleasure in inviting Dr. Rowe to deliver his address.

THE INSTITUTION OF ENGINEERS, CEYLON

Address by the Guest Speaker

R. E. ROWE, MA, ScD, MICE, AMIStructE

on

RECENT RESEARCH IN CONCRETE AND ITS APPLICATION

Mr. President and Gentlemen,

It was with very great pleasure and indeed honour that I was invited by your President to come to Ceylon to lecture to you. When I thought about these lectures, I decided that probably the best one for the so called technical session was for me to try and talk about some aspects of research and show you how it is being applied in practice and further to indicate possible ways in which it may be applied in the future. And then for my other lecture on a somewhat popular topic which was the brief given to me, I chose "Model testing of structures".

INTRODUCTION

This lecture is concerned essentially with the research on concrete carried out in recent years by the Cement and Concrete Association and its application in practice. The Research and Development Division comprises four departments dealing with materials technology, structural design, construction processes and their implications and operational research associated with digital computing. The staff numbers 120 of whom about half are graduates and the remainder technicians and laboratory assistants. In addition there is a works and services department, with about 60 craftsmen and labourers, which provides all the relevant contracting services to the research departments. I propose concentrating primarily on the structural design and construction aspects but intend to mention some facets of the materials technology work later to indicate possible future applications.

Cracking and Crack Control in Reinforced Concrete

With the advent of hot rolled deformed steel reinforcement and, more important, the limit state design concepts, considerable attention has been focussed on cracking in reinforced concrete members. An extensive investigation of some 133 beams was carried out (1, 2, 3) so that a statistical appraisal of the cracking phenomenon could be obtained. Figure 1 shows a typical comparison of the crack patterns

obtained in two similar beams, reinforced with the same percentage of plain mild steel, and deformed high tensile steel, under the same load. The crack widths in the region of uniform moment were found to be randomly distributed with a standard deviation of 0.42 of the mean crack width, and the difference between the mean values for plain steel and deformed steel was 13%, which in view of the large standard deviation is not significant. The principal parameter which affected the cracking was found to be the cover expressed in terms of the distance from the surface of the beam to the nearest reinforcing bar. Arising from this work, a simple crack width formula has been proposed and incorporated in the new Draft Code of Practice for the structural use of concrete (4); it is

$$\text{Maximum surface crack width} = 2.3\, C\Sigma$$

where C = distance from point considered either to the surface of the nearest reinforcing bar or to the neutral axis, whichever is the lesser.

Σ = apparent longitudinal tensile strain in the concrete at the point considered; this should take account of the tensile stiffening effect of the concrete in the tensile zone.

Subsequently, further tests were carried out on reinforced concrete slabs (see Figure 2) with low percentages of steel which demonstrated that the simple equation above was still applicable. With the completion of the experimental work and the associated analysis, it has been possible to set out a series of detailing rules (4) which, when complied with, ensure that cracking is controlled within acceptable limits for various environments. Further, a new theoretical approach to the problem of cracking in reinforced and prestressed concrete has been formulated; this will be published in the near future (5).

Design of Framed Structures

For some years we have been concerned with the definition of the moment-curvature and moment-rotation relation for reinforced and prestressed concrete members subjected to flexure and also flexure with axial load. More recently this study has been concerned with portal frames of which 10 have been tested with hinged feet (6) and 7 with fixed feet (7), with a view to developing better analytical techniques and also design procedures capable of dealing with all the relevant limit states. These frames consisted of a transom, having a span of 10 feet, and two columns, having a height of 5 feet, with cross-sections of 4 x 6 ins. reinforced in different ways. Tests were carried out under vertical and horizontal loading up to collapse; a typical test is shown in Figure 3. A non-linear method of analysis (8) was shown to be capable of predicting the behaviour of the frames satis-

factorily at all stages in the behaviour up to collapse and, perhaps more important, mechanism theory was shown to be sufficiently reliable for practical design purposes. As a result of these tests and other work, recommendations have been made in the draft Unified Code ([4]) which permit redistribution of moments obtained from an elastic analysis by up to 30% provided certain restrictions on the neutral axis position (which controls the rotation capacity) are complied with.

Another problem in framed structures arises from the increasing use of precast units necessitating a greater consideration of the detailing problems associated with the joints. Tests have been carried out on column-slab-column joints (see Figure 4) in which the slab is cast in-situ and the upper columns located on a dowel bar with a grouted or dry packed mortar joint; the object of the tests was to define an end detail for the column to retain full ultimate load capacity of the column. Similar tests have been carried out on column-beam-column joints, formed also with dry packed mortar and dowel bars, in which the beam was subjected to a hogging moment at the joint (see Figure 5). Detailing rules have been evolved for these joints and some of the results were reported at a symposium organized by the Institution of Structural Engineers ([9]).

A further experimental programme on half-joints (see Figure 6), such as used in precast pitched portal frames and in bridges, has been carried out ([10]). Design rules have been formulated which enable the desired ultimate load capacity to be achieved and, at the same time, control the widths of cracks under service load conditions to acceptable values.

Bridges

Some years ago, the Association was, with the Prestressed Concrete Development Group, responsible for introducing a range of standard bridge beams. These beams, particularly the inverted-T beam for use in composite slab bridges, have been widely used and have provided a very economical solution for bridges in the span range from 25-120 feet; metric versions of these beams are now available ([11]). However, for spans from 50-95 feet it was clear that a new type of beam was required which possessed the advantages of the composite slab form of construction and the distribution properties of a multicellular box construction without the need for transverse stressing. A model bridge was constructed so that the behaviour could be assessed in detail and a design procedure evolved. Figure 7 shows the inverted-T beams, placed side by side, with transverse reinforcing steel passing through holes in the webs. This steel is covered with in-situ concrete to give just the required cover and then permanent shuttering (asbestos-cement sheet) placed on the top

flanges of the beams, as shown in Figure 8. Finally an in-situ reinforced concrete slab is cast to give, in effect, a voided slab deck prestressed longitudinally and reinforced transversely. This bridge was tested to destruction and Figure 9 shows the typical deformation at a considerable overload.

The results have enabled a procedure to be laid down for determining the basic parameters for this type of deck which, when associated with the normal load distribution procedure, enable the behaviour to be predicted accurately and hence the design formulated. A new range of standard beams has been designed and these are shown in Figure 10; these beams cover the range of spans from 15 to 29 m.

Shear in Reinforced and Prestressed Concrete Beams

In our approach to the problem of shear in reinforced concrete, attempts have been made to isolate and quantify the various effects contributing to the total shear resistance. The first of these is the dowel effect which has been studied on both model and prototype beams ([12]); Figures 11 and 12 show the test specimens. From these tests, the contribution of the dowel has been assessed at between 9 and 20% for beams without stirrups and may increase to 30% for beams with stirrups at close centres. The second effect is the shear in the compression zone of the member; tests on this aspect showed that between 20 and 25% of the shear force is resisted by the compression zone ([13]). Finally, there is the aggregate interlock effect across cracks which may contribute up to 50% of the total shear force. A special test specimen and test rig was designed to study this effect; Figure 13 shows a typical specimen under test. The test specimen is initially cracked in flexure and the test rig enables a shear force to be applied such that as the force is increased when deformation parallel to the crack begins, the crack also opens in the perpendicular direction, thus simulating crack propagation in flexure. With these tests we will be studying the effect of type of aggregate, mix proportions and so on and thus, eventually, we should be able to define the shear resistance of reinforced concrete beams more precisely.

Design of Formwork

In the construction process formwork can form a very considerable proportion of the total cost and yet the attention paid to the design of formwork is small in comparison with that paid to the actual structure. Therefore, we have been undertaking research to improve this situation; this work is supported by the Construction Industry Research and Information Association (CIRIA).

The first stage was the development of a pressure balance ([14]) which was capable of continuously monitoring the pressures generated during the placing of concrete and while it stiffens; Figure 14

shows this equipment in use. Subsequently, tests on site were conducted which covered a wide range of ambient and mix conditions, rates of placing and section shapes. From these tests a pressure design chart was evolved which enables the formwork designer readily to assess the pressure relevant to his specific conditions ([15]). The second stage consisted of building a test rig, shown in Figure 15, which enabled any type of pressure distribution to be applied to various types of formwork. With this test rig we have been studying various types of standard designs of timber formwork and, by measuring the deformation characteristics, assessing the efficiency. Similarly the significance of the moisture content of the timber has been assessed; Figure 16 shows some typical results; and the effect of scarf joints has been studied. A considerable volume of test data has been acquired from which we hope to provide an improved basis for design which will increase the economy of formwork.

A further aspect of the formwork problem is that associated with striking times. In an attempt to provide a rational basis for specifying the striking times associated with different elements in various environments, a investigation of the early properties of concrete has been in progress for some time. In this tests on various concretes from 4 hours to 28 days have been carried out to derive the maturity law i.e. the relation between time and temperature and strength. Similar studies have been carried out to define the early bond and creep properties of concrete and then to relate these to the behaviour of concrete beams loaded to various proportions of their working load at early ages.

To enable the maturity law to be applied to practical members, having considerable volume, it is necessary to define the temperature distribution throughout the members which is generated by the heat of hydration of the cement and affected by the insulation properties of the formwork and the ambient conditions. Some typical results obtained in this study are shown in Figures 17a and 17b; these two figures show clearly the effect of the insulation properties of the formwork.

From these studies it should be possible to provide designers with the means of firstly deriving the temperature distribution in members during the important early hours after concreting; secondly, a means of deriving the strength variation throughout the member from the maturity law and thirdly, therefore, a procedure for specifying realistic striking times for the formwork. In addition, the important phenomenon of thermal stress and cracking can be assessed by the designer and, therefore, appropriate design or construction measures taken.

Concrete Roads

The thermal effects in concrete roads are, or may be, greater than in buildings since there is the additional effect of solar heat gain to

consider. This problem is also being studied by casting small areas of concrete slabs, 10 ins. thick, and using different curing compounds; the temperature history at different points in the slabs are recorded automatically. Some results from this series of tests are shown in Figure 18; from this it can be seen that the relative efficiency of different curing regimes can be assessed. This particular study was stimulated by the phenomenon of "plastic" cracking which was observed on site; the reasons for this cracking were sought and from the envestigation, satisfactory construction techniques were evolved to preclude the future occurrance of "plastic" cracking.

Another problem which has concerned us for some time is the skid resistance of concrete roads. The surface texture has been demonstrated to be the most important parameter, the micro-texture or harshness for low-speed skidding and the macro-texture for high-speed skidding. To achieve a satisfactory macro-texture, a grooving technique has been developed for both hardened concrete (to restore adequate skid resistance) and fresh concrete (to give the desired properties at the time of construction). Various patterns of sawn grooves ([16]) have been cut in a section of the M1 motorway to see how they behave in service for comparison with laboratory tests on a wear wheel. In situ tests to give the sideway force and braking force coefficients ([17]) have shown the most efficient depth and spacing of grooves. Work is now in hand, jointly with the Ministry of Transport, to develop equipment which is capable of sawing the required groove patterns more quickly than at present.

For freshly-placed road concrete, a re-vibration technique has been developed which enables a pattern of grooves, similar to the sawn pattern, to be imposed in the plastic concrete. The plant is shown in Figure 19; this follows behind the conventional paving train and the vibrating float with protruding ribs is drawn across the concrete leaving the pattern shown in Figure 20. This technique obviously has very considerable potential since the cost of the grooving operation is very low while achieving the optimum surface texture for both low and high speed skid resistance.

High Strength Concrete

I would like to consider two aspects of the research on materials technology which have great potential for the future. The first of these is the achievement of concrete strengths up to 15,000 lb/in^2 while using conventional concrete, aggregates, and compaction techniques, although with some selection. We have studied this problem and have evolved mix design procedures ([18]) and also established the properties ([19]) i.e. strength in compression, tension, dynamic and static modulus and creep and shrinkage characteristics, of concretes in the strength range from about 12,000 to 15,000 lb/in^2. Some typical results are shown in Figures 21 and 22.

This material is of value for prestressed concrete beams, particularly in bridges, since it allows the use of much shallower sections with resultant economy in approach works and embankments. For example, using the standard box beams (11) designed for 120 feet span with a concrete strength of 7500 lb/in² at 28 days, it is possible with the same section to achieve a span of 150 feet if the concrete strength is increased to about 14,000 lb/in² at 28 days.

The second aspect arises from our research to determine the true ultimate strength of the bonding agent in concrete namely the cement paste (20). We have been using powder metallurgy techniques to compact dry cement under high pressure to reduce the porosity and subsequently by hydration to reduce the porosity further. Figure 23 shows the relation between compacting pressure and porosity and it will be seen that strengths up to about 55,000 lb/in² in compression can be obtained. Typical moduli of elasticity are given in Figure 24 and creep and shrinkage date in Figures 25 and 26 respectively. This material, provided mass-production is possible, offers considerable potential for use both in the construction industry and in other industries; we are at present exploring possible uses for it.

Conclusions.

Mr. President, Gentlemen—I hope by showing some of the current work of the Association I have been able to indicate the very great relevance of it to practical design and construction. Our aim is always to undertake research that contributes to the efficiency of the design and construction process as a whole so that more construction can be achieved with the available financial resources. Since the latter are always less than desired, whether in England or Ceylon, it merely serves to emphasise the need for correctly oriented research programmes.

Discussion

Dr. Balasuriya:

I was particularly interested in your remarks on shear since, although the individual components have been known for some time, no one to my knowledge has succeeded in separating them in any quantifiable manner.

Dr. Rowe:

I should hasten to say that we have not yet quantified all the aspects of shear! However, by defining the compression zone shear precisely in our tests and also the dowel shear, we have clearly demonstrated the order of magnitude of the aggregate interlock effect. The special test specimens I illustrated will, I believe, provide valuable data on this effect and then, possibly, we can provide a more rational and accurate treatment of shear.

Mr. Kulasinghe — One comment I would like to make. Dr. Rowe's remarks are certainly interesting in the work that has been done, on high strength concrete, specially on cement paste. This has been engaging our attention for sometime and the results achieved by us are quite encouraging. I think a pointer to this would have been available in the process which has been used for the manufacture of calcium silicate bricks and you get every high strengths from such mixtures. As you know calcium silicate bricks are pressed at about two tons per sq. inch using 8-92 mixture of lime roughly. There is a physio-chemical reaction that takes place and the compaction gives strengths which are not associated with such mixtures. I am waiting for your research paper which I hope will be available to us very soon, so I will not plague you with a lot of questions but I would like to know the type of pressures you have to use in a hydraulic press to get some of these very high pressures because they are much more than we use in powder mettallurgy.

Reply to Discussion

Dr. Rowe—You cannot get anything from nothing, so we need to base the strength from the pressures you can put in. If you have a material which you can put say 600,000 lbs. pressure, that is high pressure which can only be obtained with very heavy presses but a pointer to be made is that it might have application to another construction.

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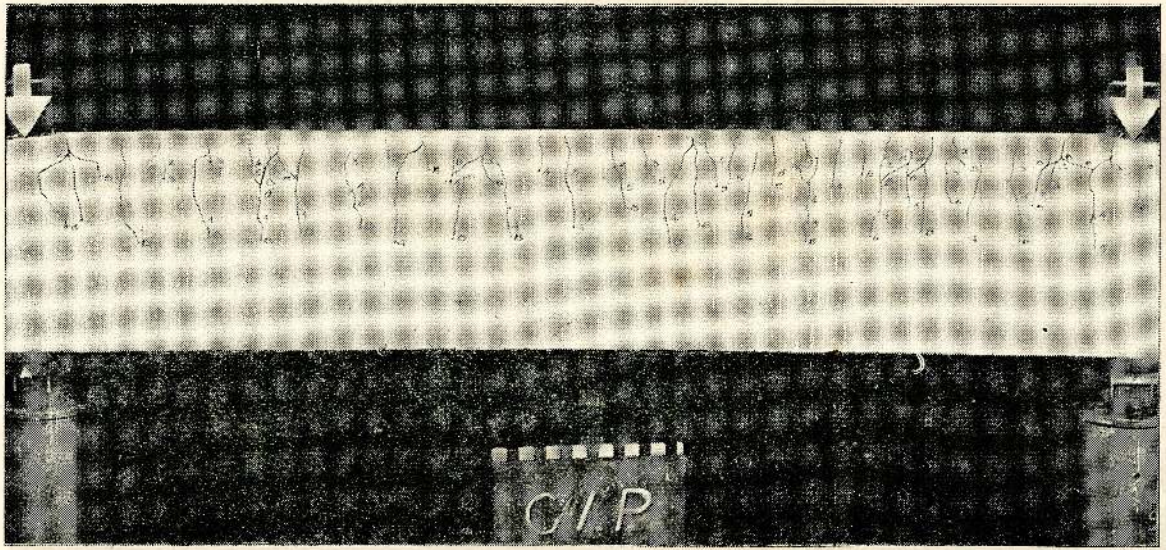


Fig. 1. (*a*) Beam CIP—Plain round steel, $\frac{1}{2}''$ side cover

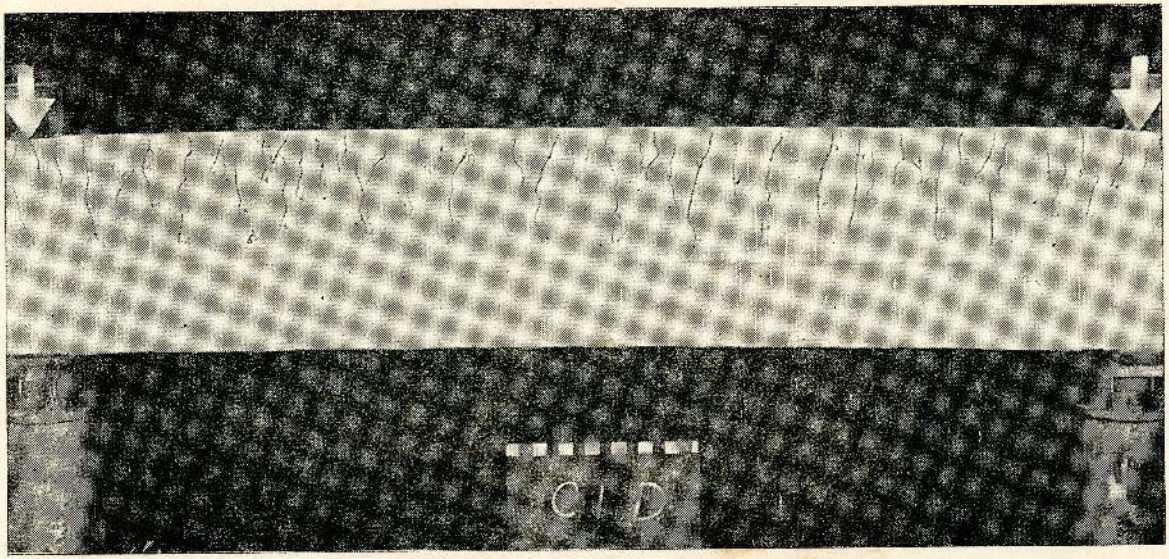


Fig. 1. (*b*) Beam CID—Deformed steel, $\frac{1}{2}''$ side cover

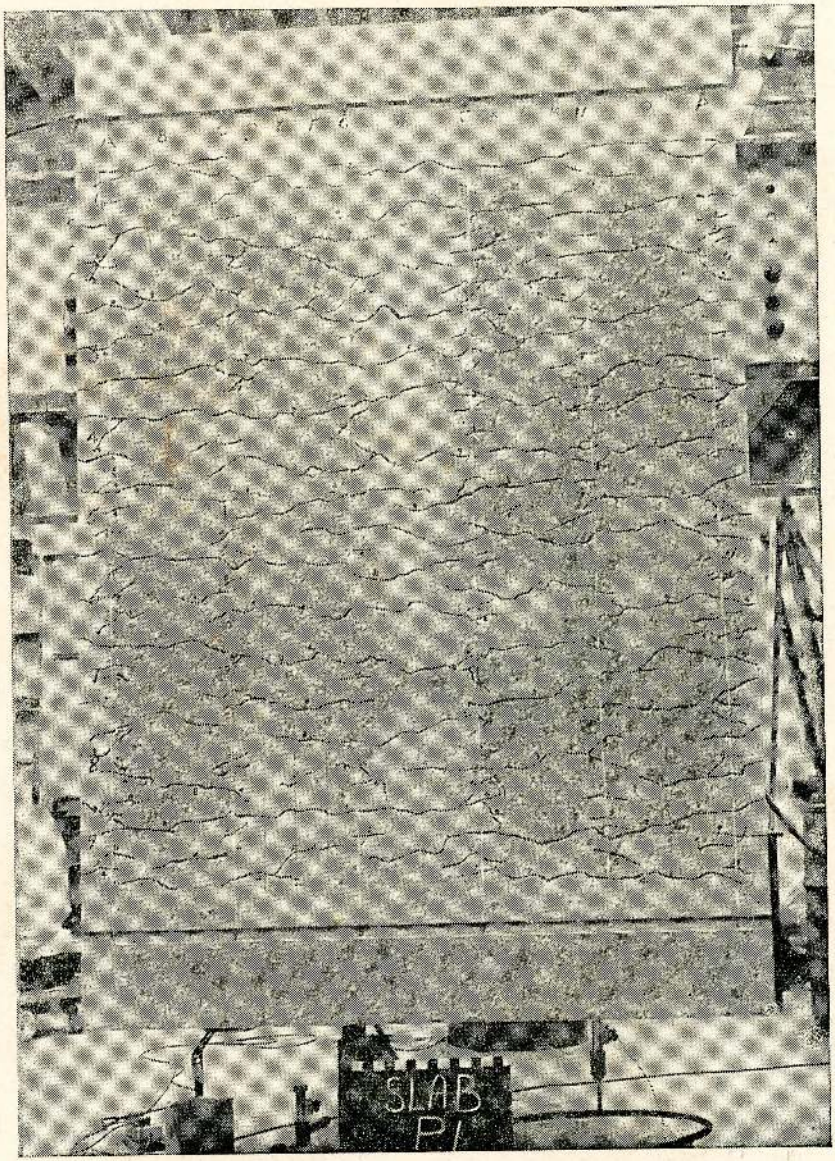


Fig. 2. Crack pattern on a wide R.C. slab, 6 ins. deep, subjected to uniform moment.

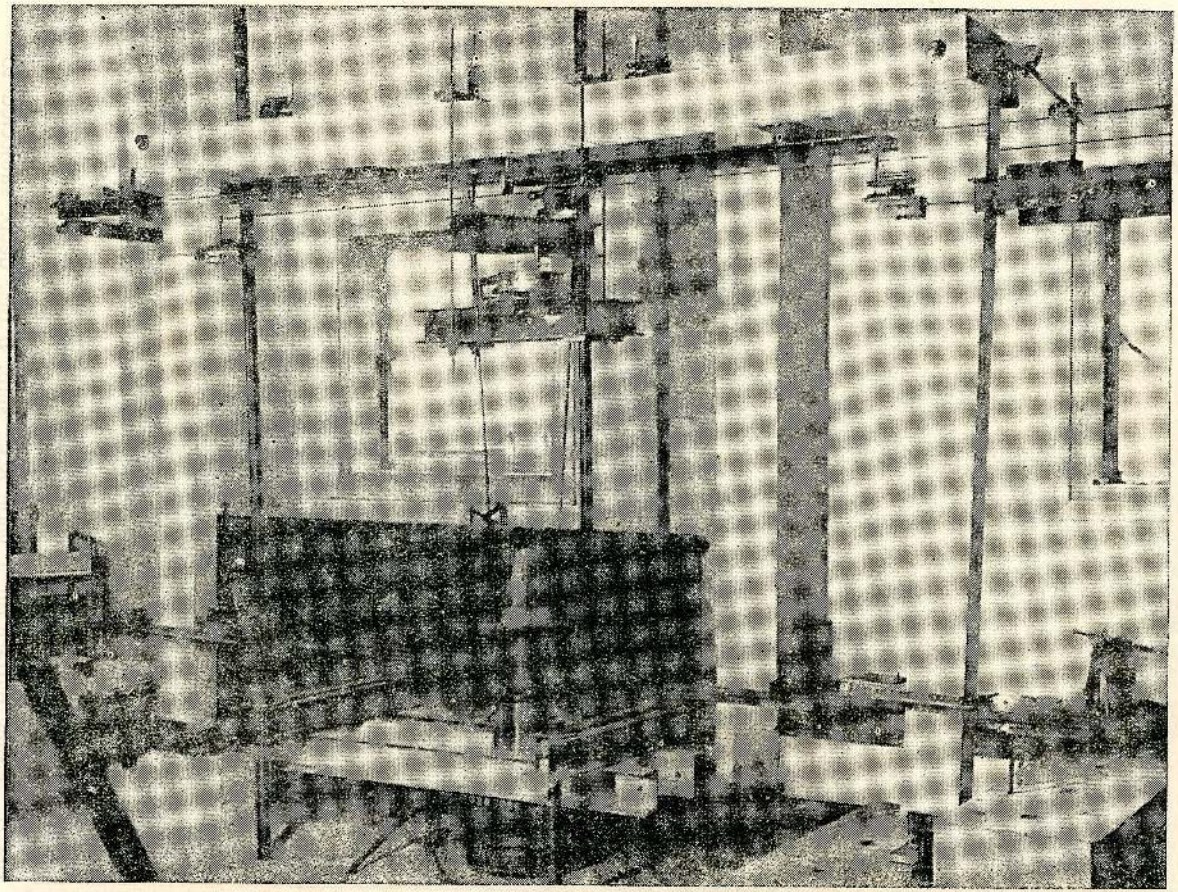


Fig. 3. Pinned portal frame under test

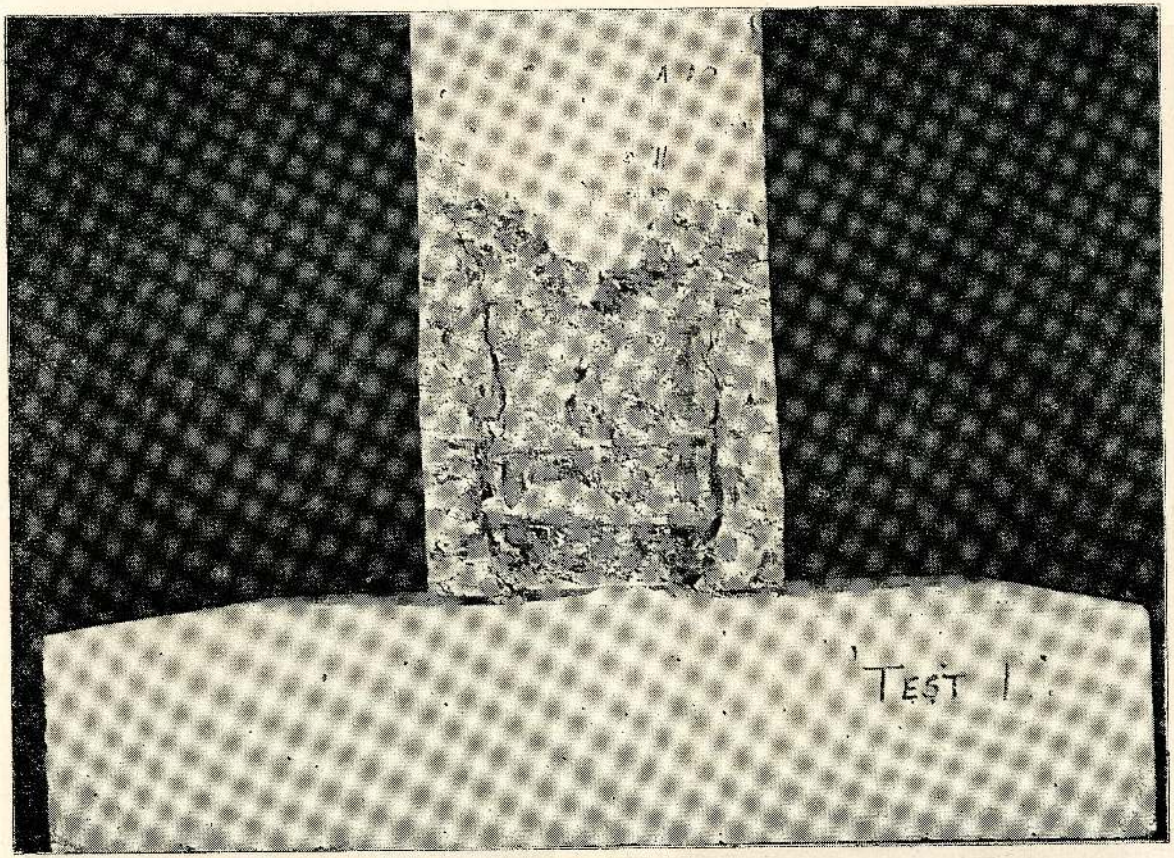


Fig. 4. Test on a column-slab-column joint

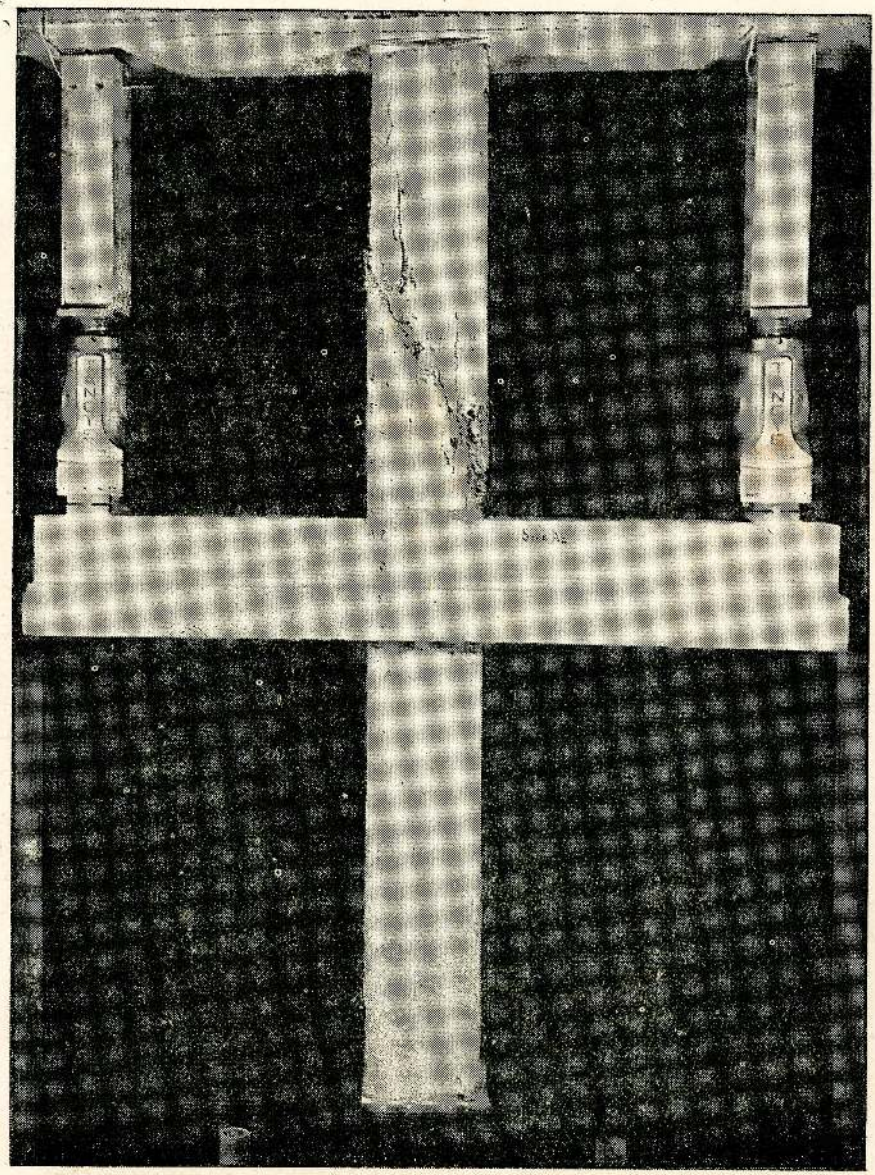


Fig. 5. Test on a column-beam-column joint

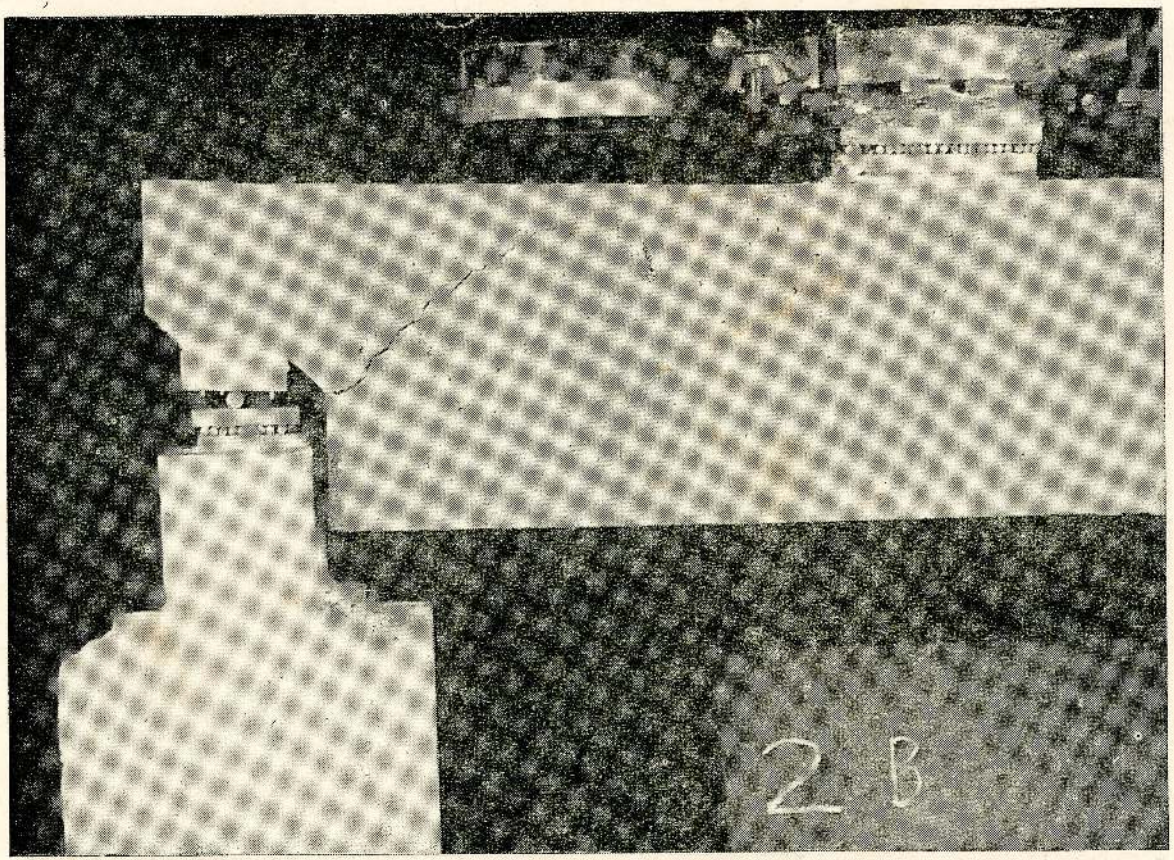


Fig. 6. Test on a half-joint at the end of a beam

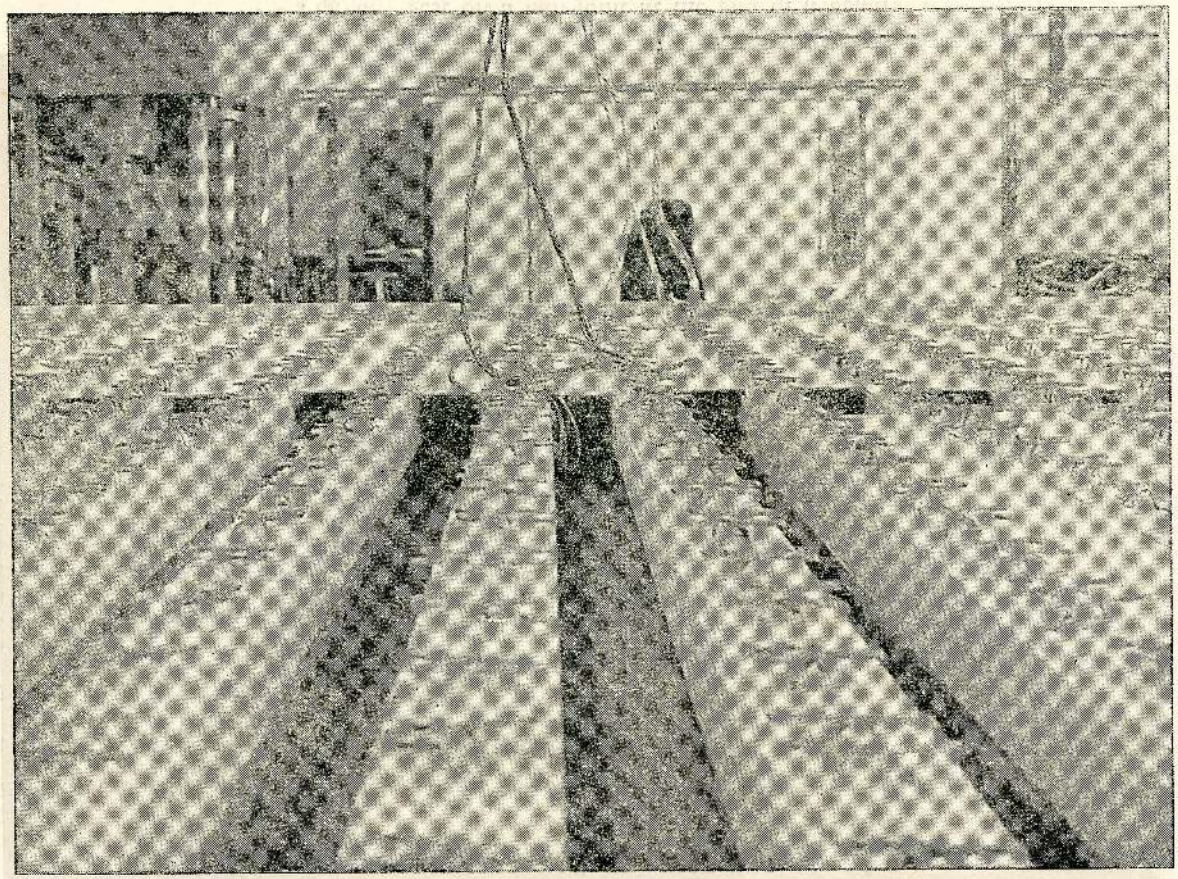


Fig. 7. First stage in construction of voided slab deck

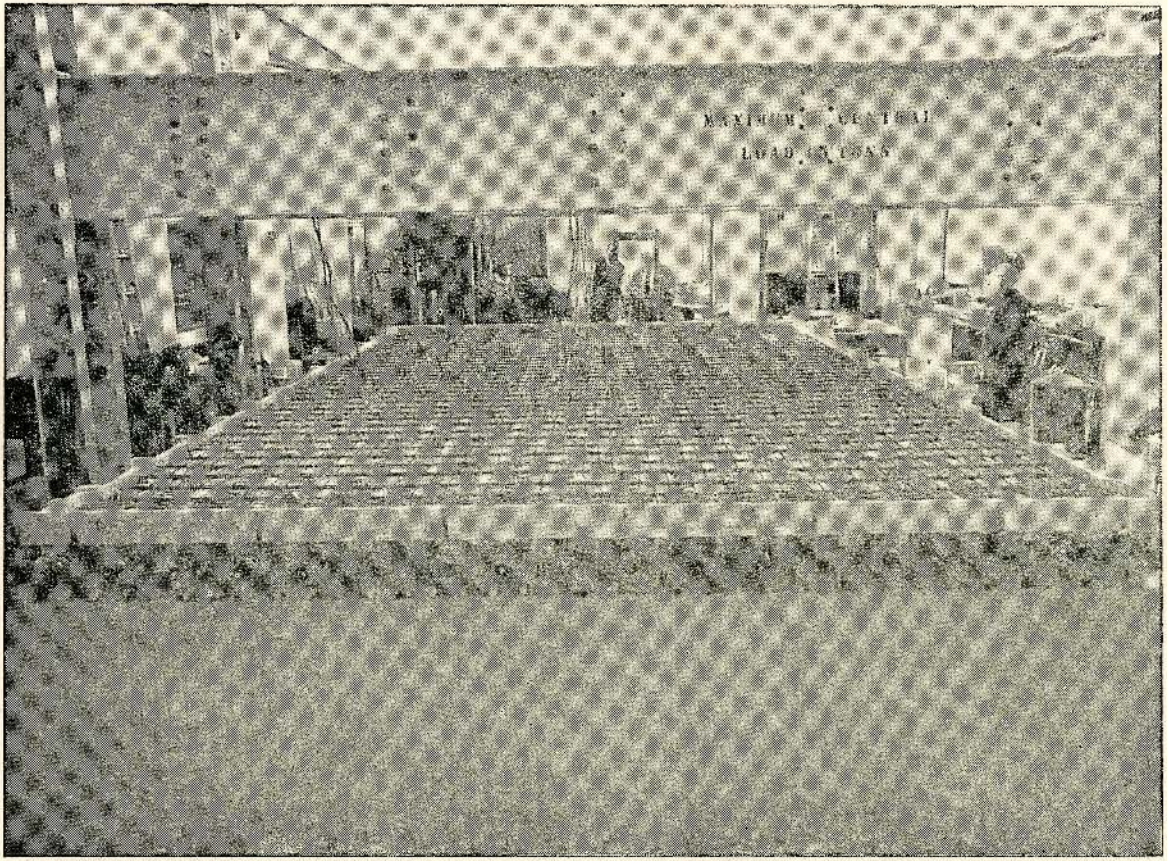


Fig. 8. Second stage in construction of voided slab deck

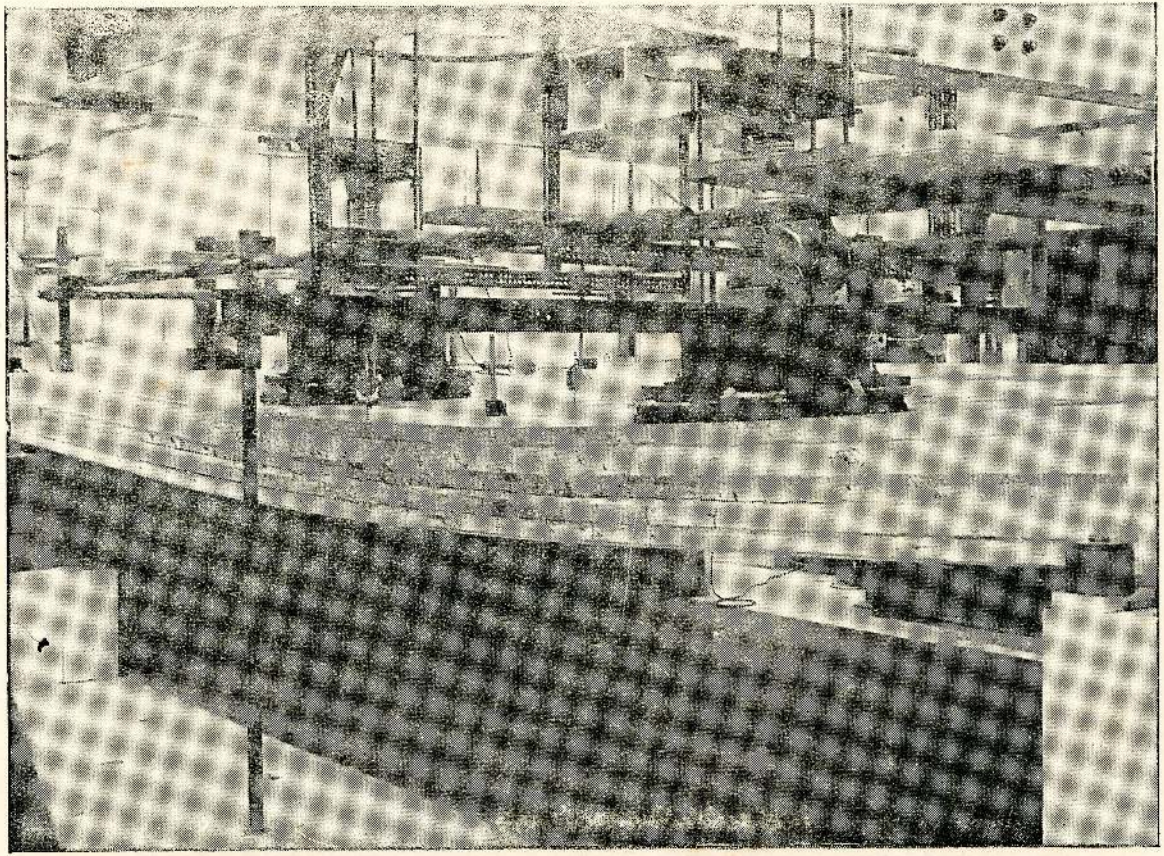


Fig. 9. Completed voided slab deck under a severe overload before failure

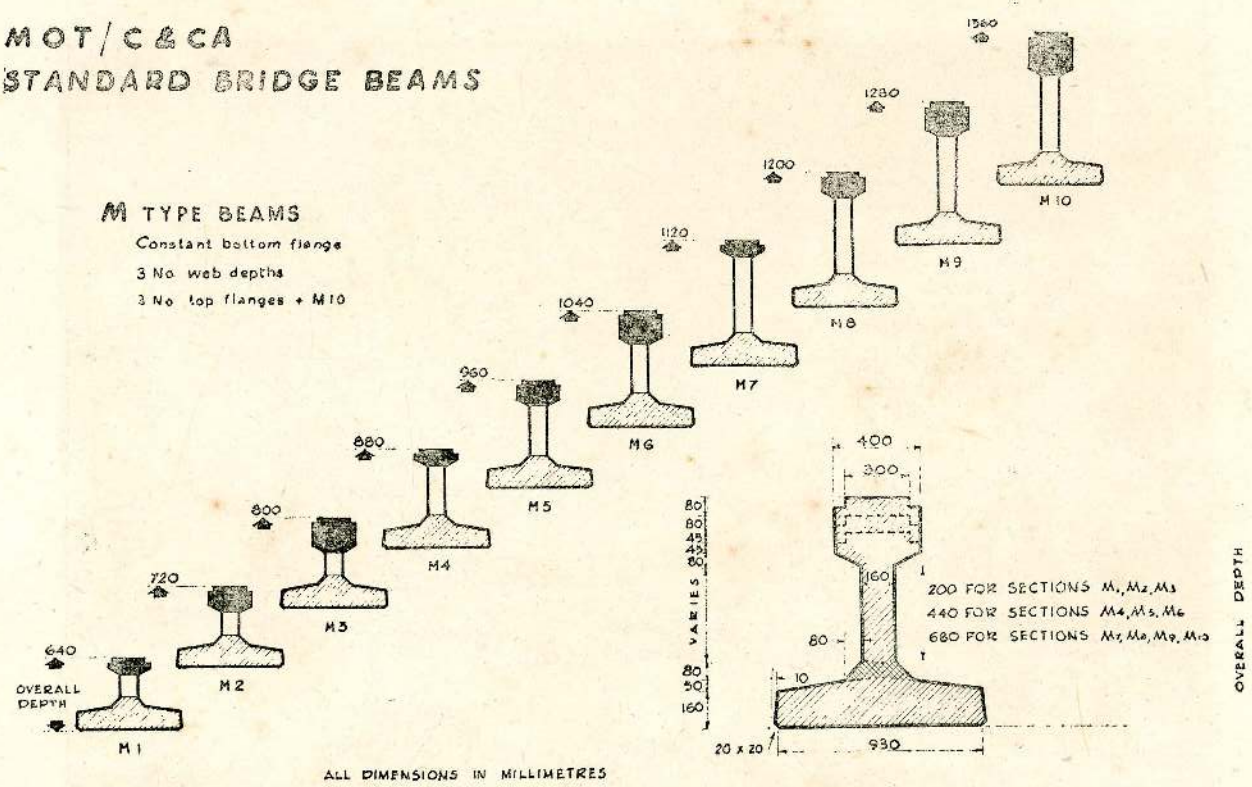


Fig. 10. New range of inverted-T beams.

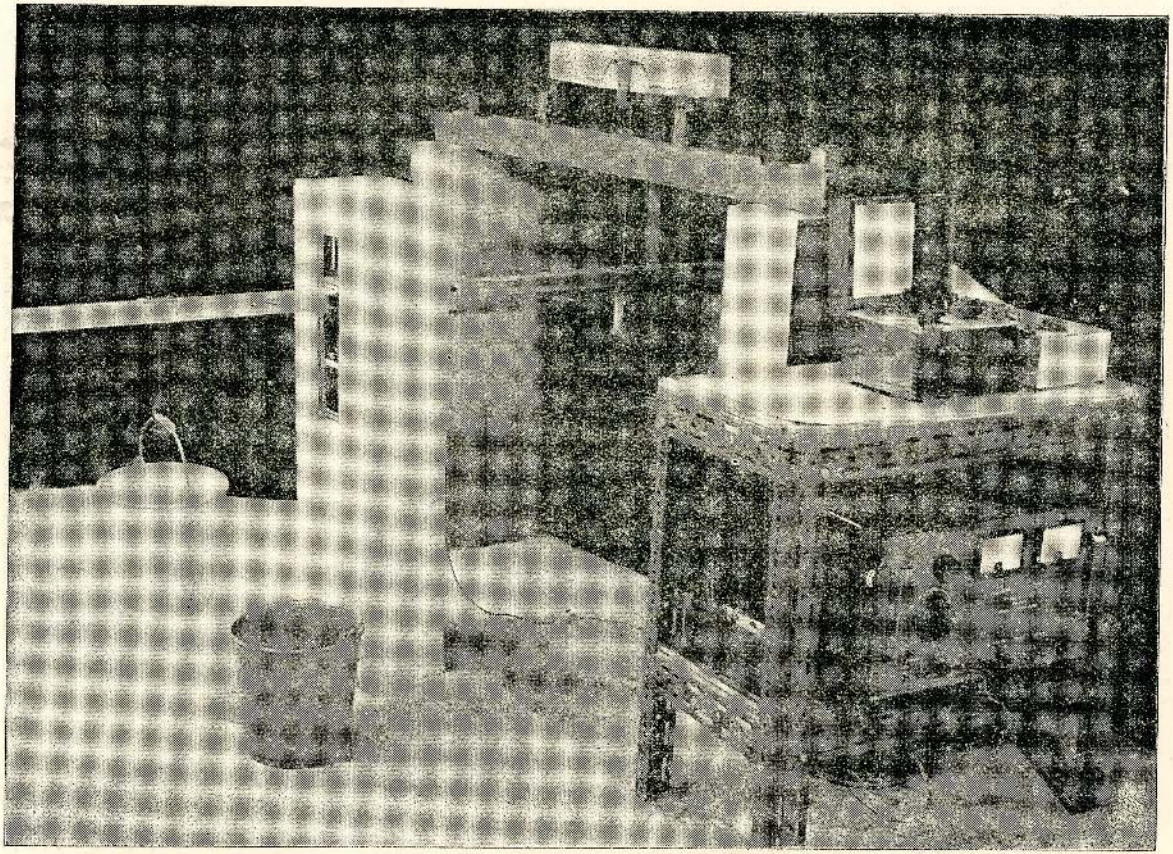


Fig. 11. Model beam under test

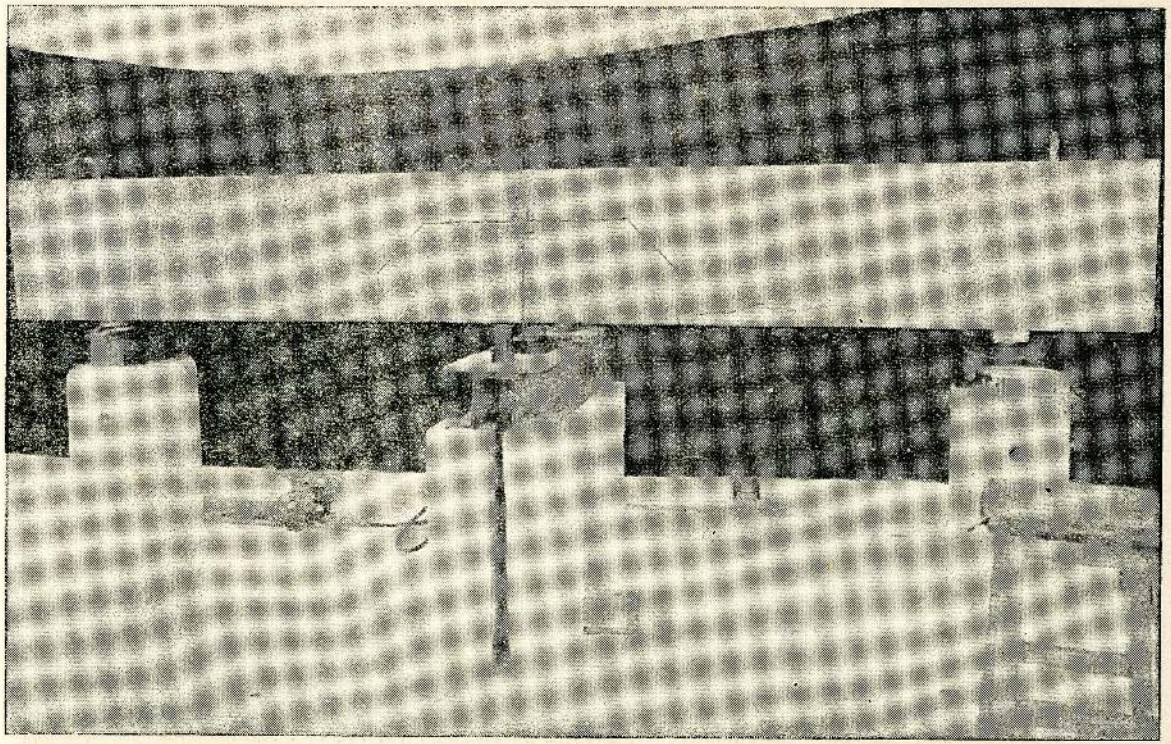


Fig. 12. Prototype beam under test

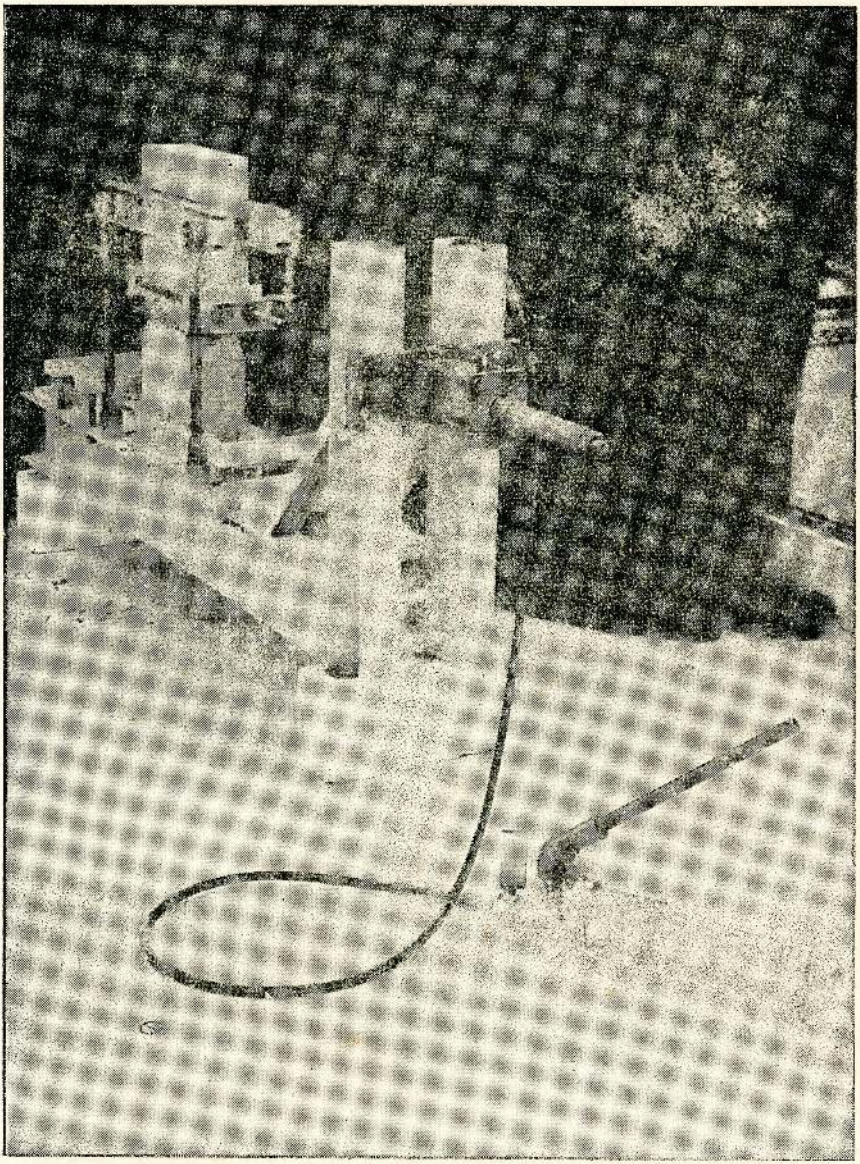


Fig. 13. Test rig & specimen for aggregate interlock investigation

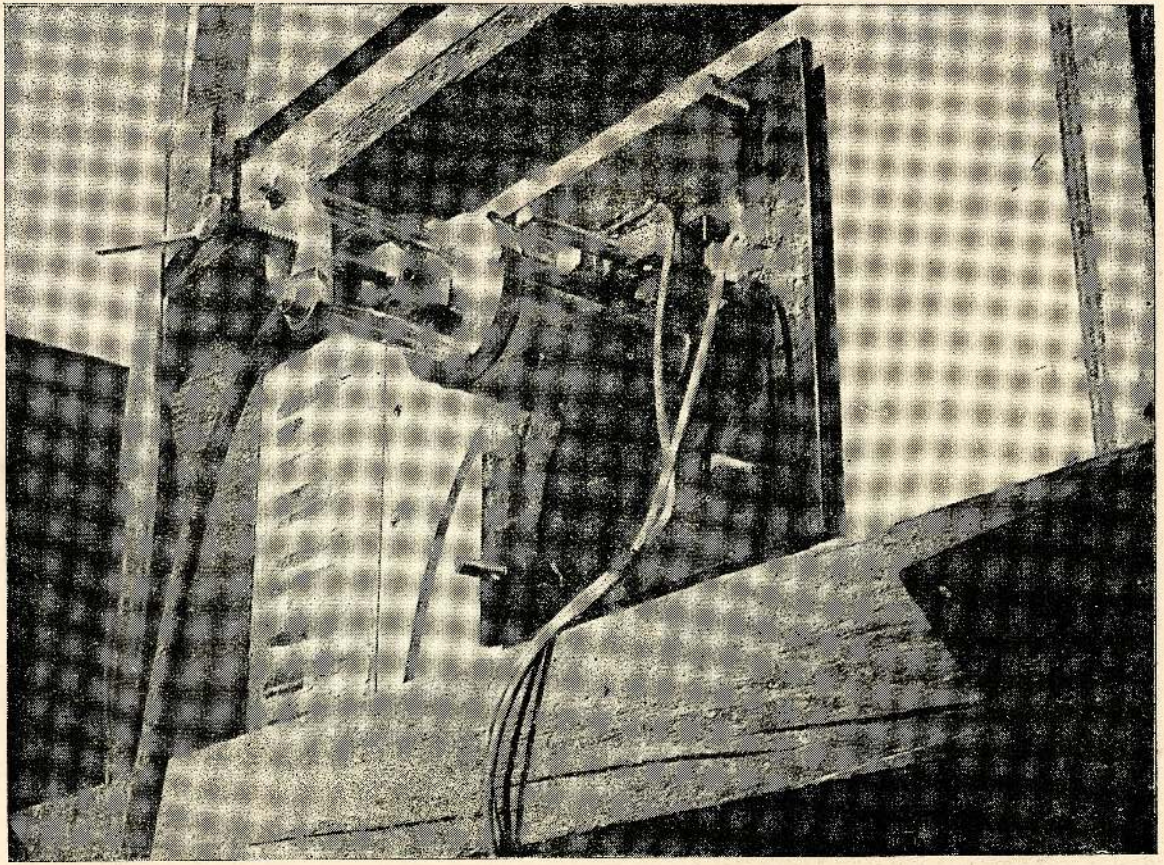


Fig. 14. Formwork pressure balance

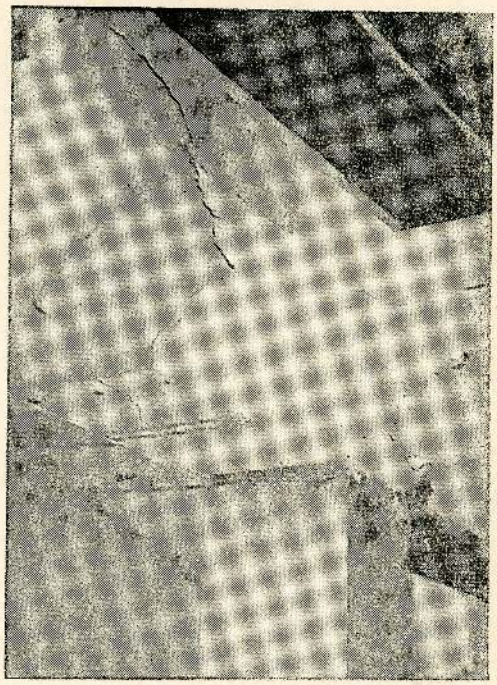
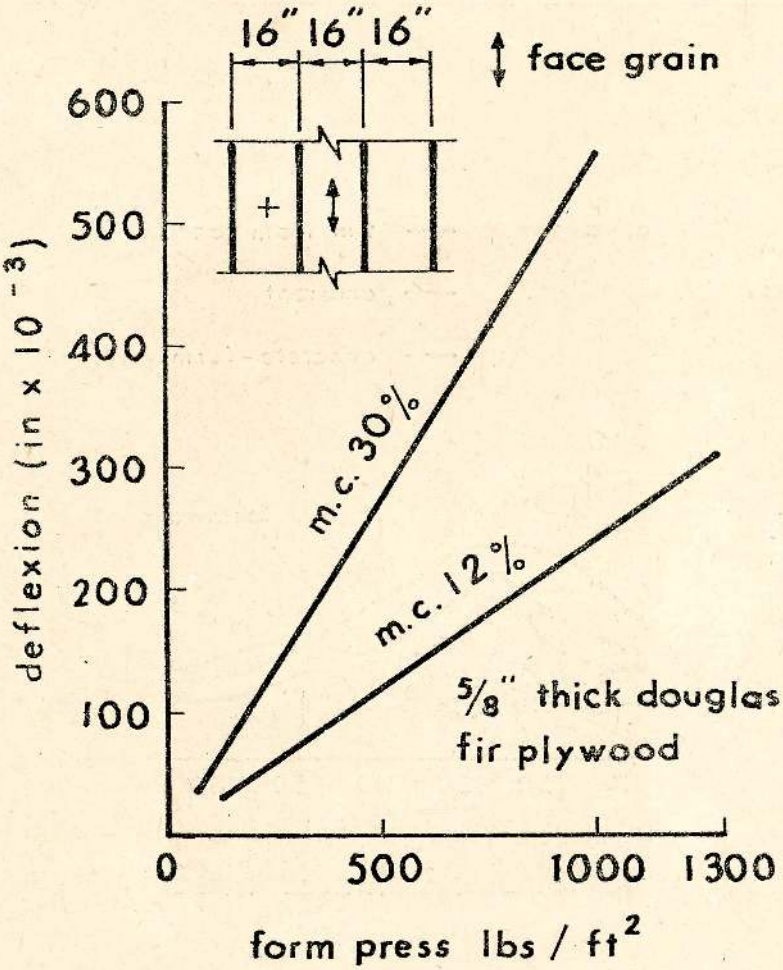


Fig. 15. Formwork Test Rig



EFFECT OF MOISTURE CONTENT

Fig. 16

r.m.d. steel pans

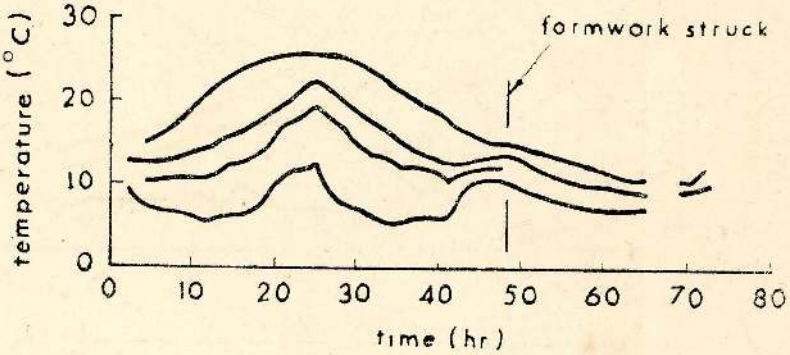
o.p.c. 580 lb/yd^3

— external form face

— 9 in from face (℄)

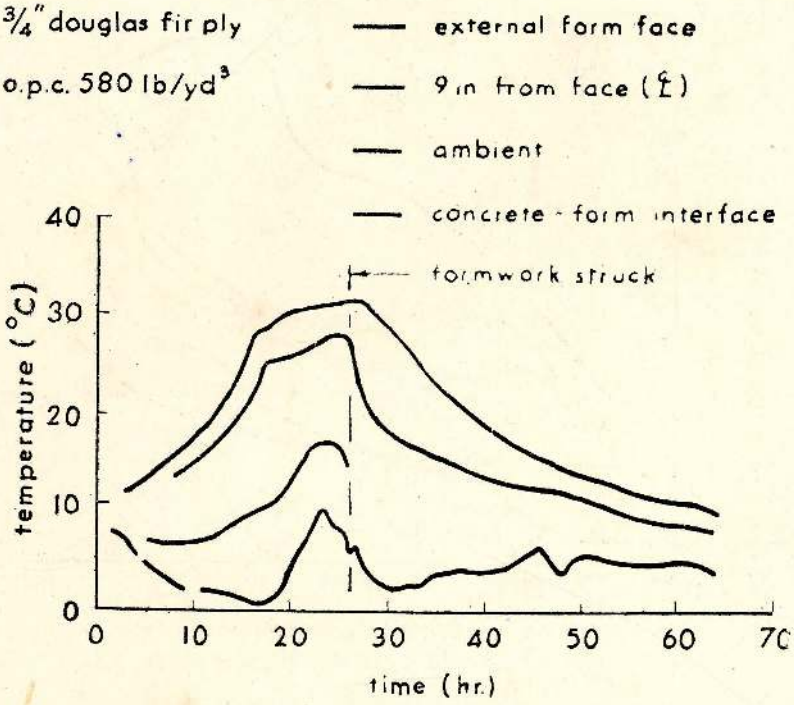
— ambient

— concrete-form interface



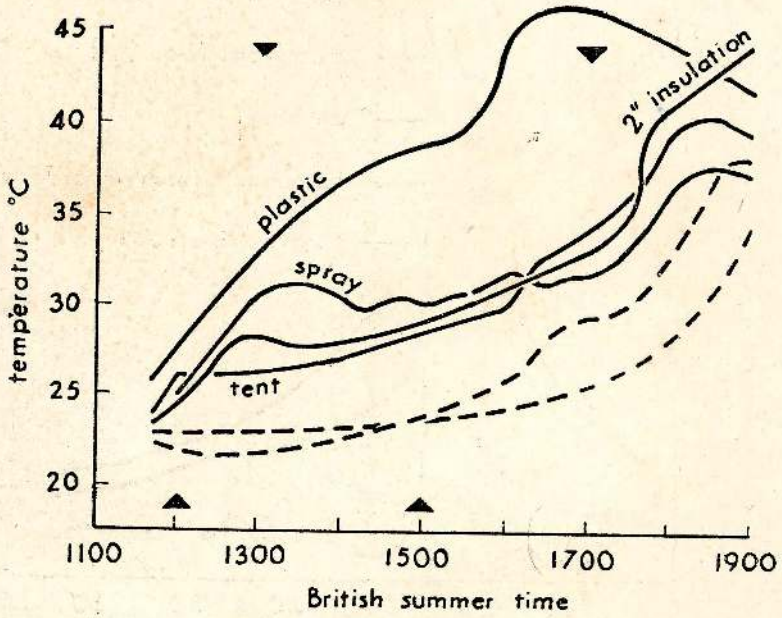
EARLY CONCRETE TEMPERATURES IN FORMWORK

Fig 17 (a)



EARLY CONCRETE TEMPERATURES IN FORMWORK

Fig 17 (b)



CONCRETE SLABS – PROTECTION METHODS

FTg. 18

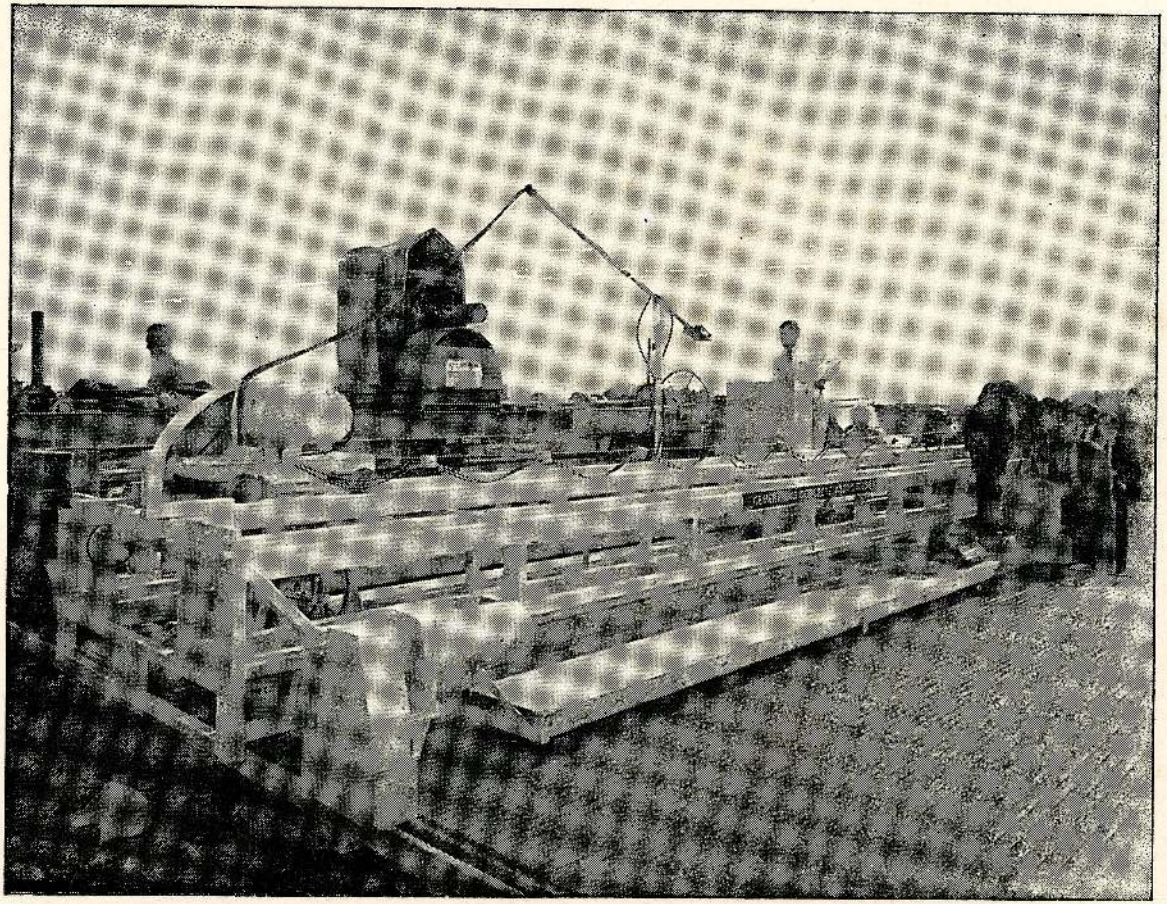


Fig. 19. Plastic grooving machine

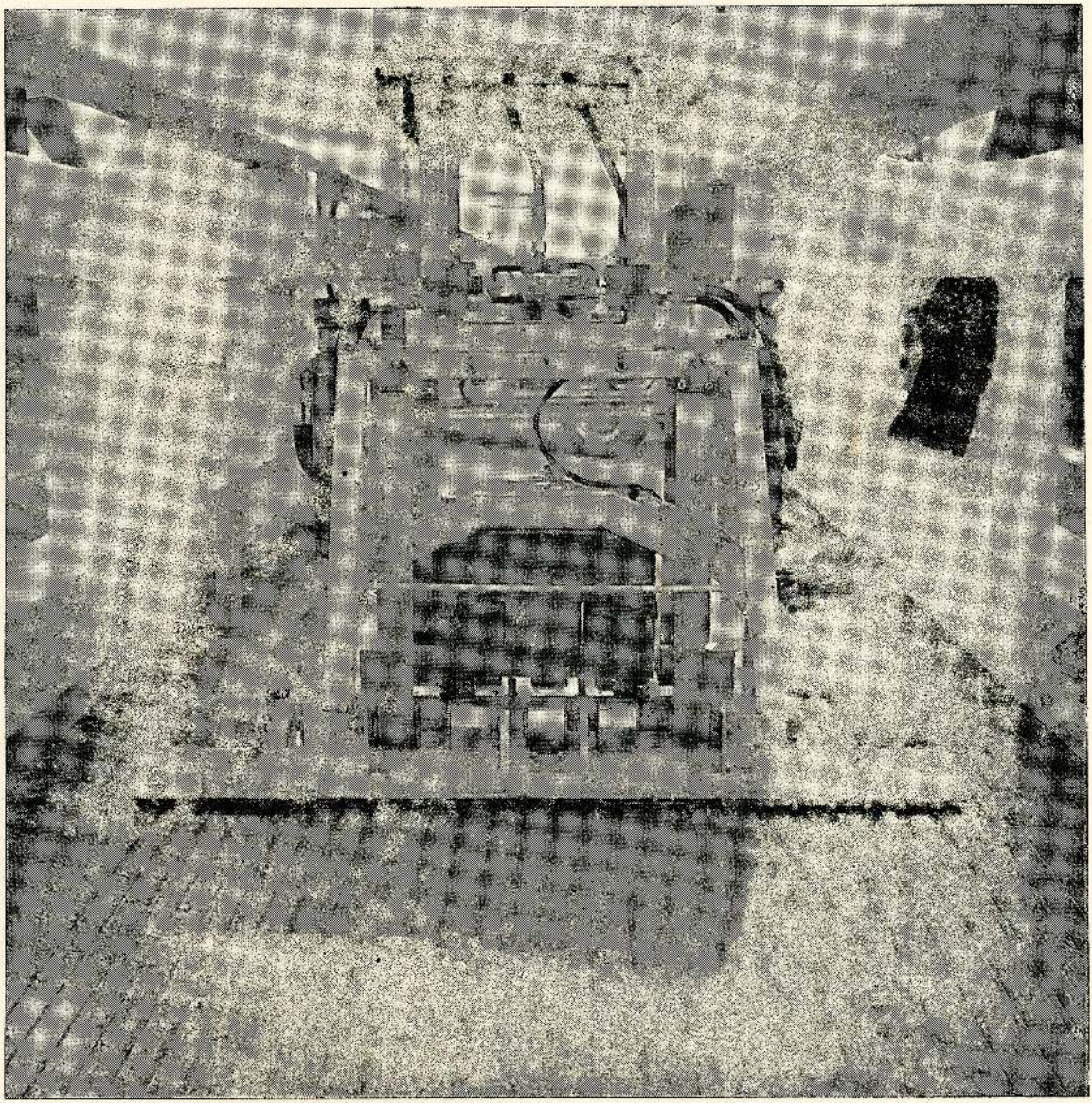


Fig. 20. Typical grooves formed in plastic concrete

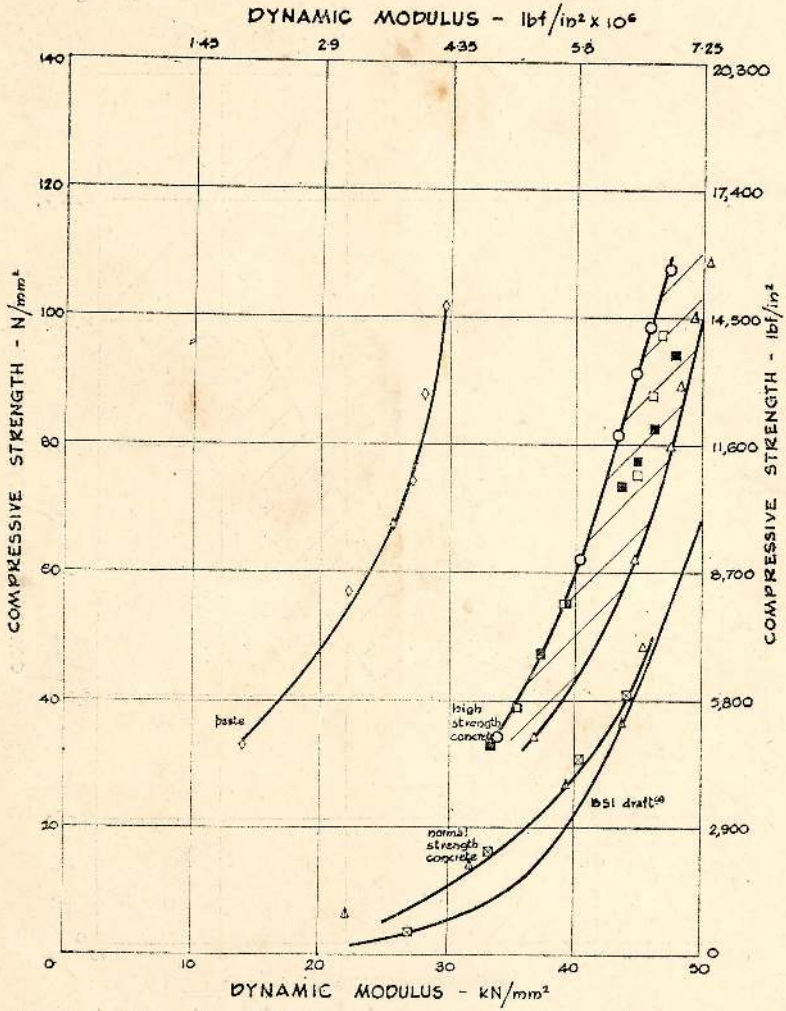


Figure 21: Relationship between dynamic modulus and compressive strength of concrete

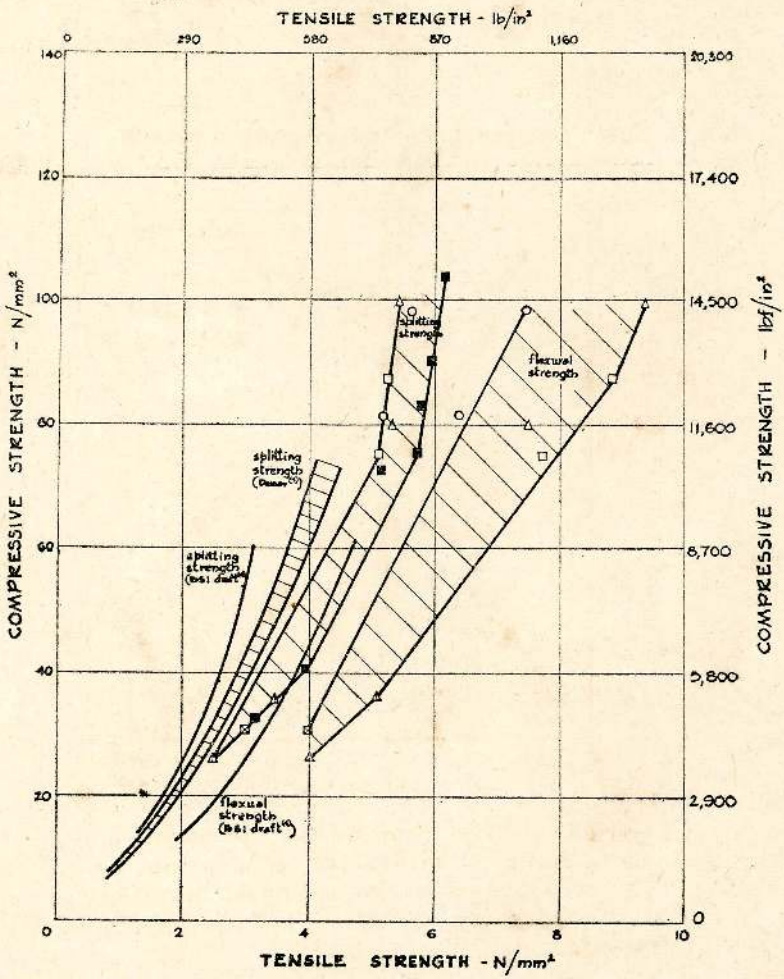


Figure 22: Relationship between tensile and compressive strengths of concrete.

The properties of cement paste compacted under high pressure

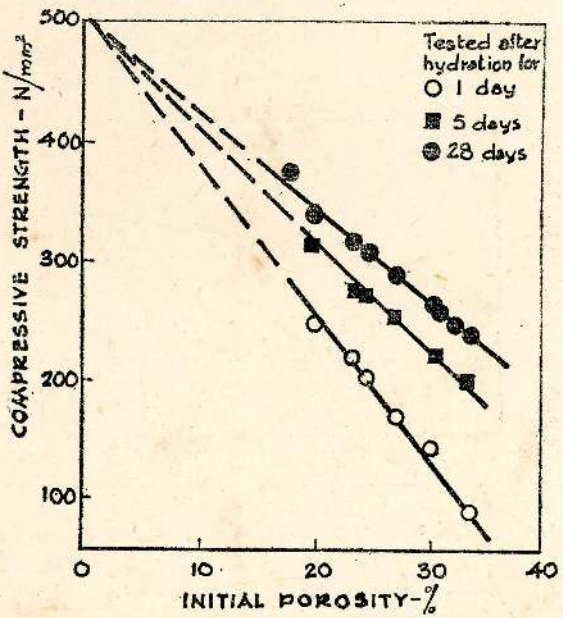


Figure 25: The compressive strength of 32 mm diameter compacts of cement D/5 versus the initial compact porosity after hydrating at 20°C for different periods.

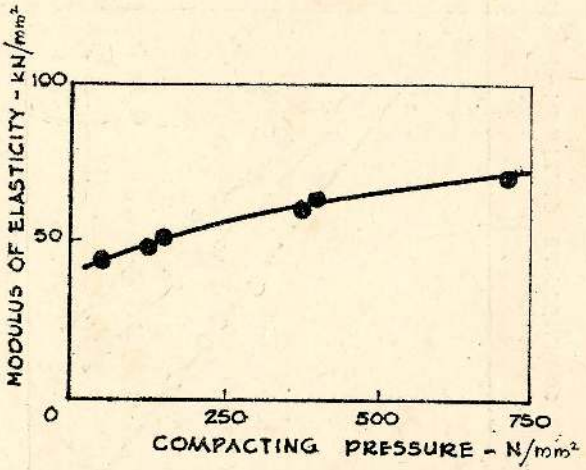


Figure 24: The modulus of elasticity of pressed cement cylinders made at different compacting pressures after hydration for 28 days at 20°C.

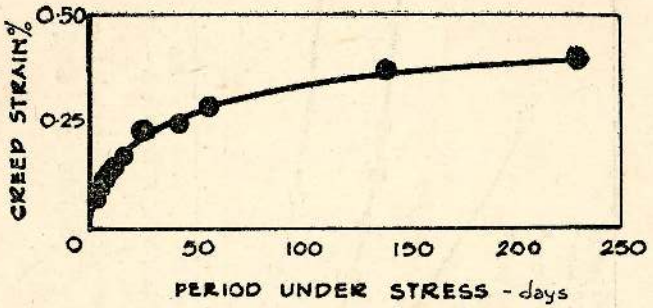


Figure 25: The creep strain of pressure-compacted cement stressed at 77 N/mm² after hydration for 28 days at 20°C.

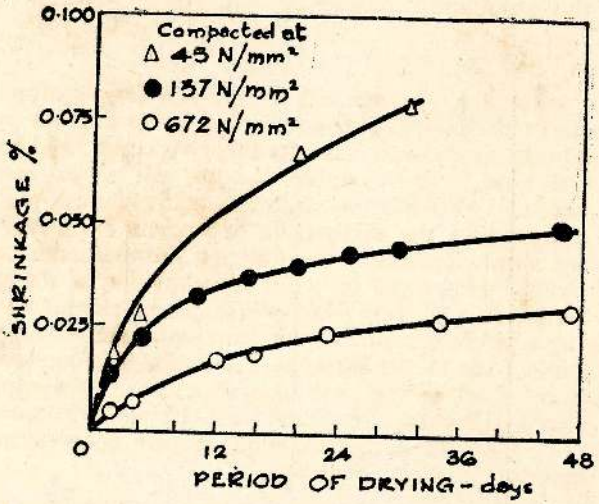


Figure 26: The drying shrinkage of pressed cement pastes at 65% relative humidity.

LECTURE

ON MODEL TESTING OF STRUCTURES

by R. E. Rowe, MA, ScD, MICE, AMIStructE

Mr. President and Gentlemen,

As I said this morning, my lecture is somewhat on a popular topic for this afternoon.

Introduction

Structural design has reached its present degree of refinement mainly through the improvements afforded by techniques in mathematical analysis; the classical elasticity theory was followed by various theories and now with computers both of these have been further extended. However, as with all mathematical models, the accuracy obtained in the analysis is dependent essentially on the necessary assumptions made in formulating the mathematical model and how closely this relates to the true behaviour of the structure. The need to make simplifying assumptions can be eliminated however by producing a physical model of the proposed structure in which the characteristics of the model materials represent, to some scale, those of the material used in the prototype structure. This approach to design, which has been re-discovered over the past 15 years, is probably the oldest known design technique having been recommended by Michelangelo some 400 years ago.

In this public lecture, I propose showing its use in assisting in the design of certain structures to demonstrate its viability as a design tool in its own right.

Model analysis and testing

Model analysis and testing involves the following processes:

(i) the manufacture of a model of the envisaged structure using appropriate model materials;

(ii) the testing and observation of the behaviour of the model under prescribed loading conditions;

(iii) the prediction of the behaviour of the actual structure using the laws of similitude;

and (iv) the design of the actual structure on the basis of its predicted behaviour.

In the manufacture of the model all the relevant boundary conditions can be simulated or, if appropriate, certain simplified boundary conditions can be introduced. In selecting model materials certain factors must be borne in mind; these are:

(*a*) there should be an affinity between the stress/strain relations of both model and prototype materials either in the elastic range or over the entire range depending on the problems being studied;
(*b*) Poisson's ration, being a dimensionless quantity, should be the same for both model and prototype materials;
(*c*) the model material should be capable of easy fabrication to the required form and, for certain types of model, should be able to simulate the construction procedures to be employed on the prototype.

A discussion of the various types of model test and also of model materials is given elsewhere ([1], [2]).

Some examples of model testing

1. Commonwealth Institute Roof ([3])

Figure 1 shows the completed structure; the roof consists of four warped hyperbolic paraboloids, formed as a lattice in precast and prestressed concrete, on a plan area of 186 ft. 6 in. by 186 ft. 6 in. Each of the warps has its four corners at different levels and the primary members run parallel to the free edge as shown in Figure 2. This figure shows the model to a 1/32 scale in Perspex which was made to study the feasibility of the proposed structure. From a series of tests in which the boundary conditions were varied it was possible to show that the original concept included members which would buckle under load; hence a revised design was prepared, which was based on the findings of the model test, for the final structure.

Smithfield Poultry Market Shell ([4])

When the design for the roof of the new Smithfield Poultry Market was conceived, it was considered that an elliptic paraboloid shell, 225 x 128 ft. in plan and with a rise of only 30 ft. along a diagonal, would be the most appropriate solution. This shell, some 3 in. thick, was to be supported on prestressed edge beams in turn supported by columns at differing centres. Certain problems arose namely:

(i) how much diffusion of prestress from edge beam to shell would occur?
(ii) what would the distribution of column reactions be?
(iii) would buckling be caused by shallowness of shell?
(iv) how much deflexion would occur during construction and hence how difficult would the striking of the shuttering be?

To obtain this type of information a realistic model test on a micro-concrete model was carried out to a 1/12 scale.

Figure 3 shows the shuttering for the model with the reinforcing steel in position; the model thickness was 0.25 in. Figure 4 (*a*) shows the soffit of the model after casting and, for comparison, Figure 4 (*b*) shows the interior of the actual shell after completion. An extensive series of tests was carried out to answer all the questions raised by the designers and the shell was finally tested to destruction; Figure 5 shows the buckling failure that was obtained. I should hasten to add that the load required to cause this type of failure was many times greater than that for which the actual shell was designed.

The new Liverpool Cathedral (2)

When the structure, shown in Figure 6, was being designed certain facets necessitated special consideration. The most important of these was the interaction between the 16 buttresses, the compression and tension ring beams and the conical shell, itself composed of orthogonal ribs with an in situ top flange. The scale of the structure, 220 ft. high and a diameter of 345 ft. at foundation level, and its design life, 500 years, also merited special study. Therefore a micro-concrete model to a scale of 1/30 was built and tested under many different loading conditions; Figure 7 shows the model under test. This figure shows the simulated dead, live and wind loadings applied to the model. A further test was carried out to simulate the effect of an aircraft crashing into the main compression ring beam, a possibility during a 500 year life. I'm glad to report that the strength of the structure is adequate for at least two such events during its life!

Cooling Tower (5)

The demands of power stations for increased cooling capacity have led to the design of hyeprbolic paraboloid cooling towers up to about 375 ft. high. However at this height wind loading problems become considerable and wind tunnel tests on very small scale models have indicated that buckling might well become a problem. For this reason the Central Electricity Generating Board wanted tests carried out on a larger scale model in microconcrete which took account of the construction tolerances in the field. For this reason a 1/25 scale model of a proposed design for a tower, 325 ft. high and 275 ft. in diameter at its base, with a 5 in. wall thickness, was built. The tolerances required the wall thickness of the model to be 0.200 ± 0.020 in. and to include two layers of reinforcing steel. Figure 8 shows the shuttering for the model; Figure 9 the construction procedure; Figure 10 the interior of the tower after some of the shuttering had been removed; and Figure 11 the finished model. The loading system to simulate the wind pressure effects is shown in Figure 12 and the final failure mode in Figure 13.

While these tests were in progress, the collapse of three cooling owers at Ferrybridge occurred. This event was reflected in more intensive testing at various stages in the behaviour of the model tower including fairly detailed studies of the effect of settlement on the supporting columns. A detailed report on this study is being prepared which should facilitate future design of cooling towers.

Hammersmith Flyover

This flyover ([6]), shown in Figure 14, was the first of the elevated spine beam structures erected in England. Being required on a very congested site, the use of precast units was a primary factor in the design concept but this implied that the normal procedure for assessing the ultimate strength was suspect by virtue of the various joints. A micro-concrete model to a 1/12 scale was therefore built of the critical section adjacent to one of the columns; the model simulated all aspects of the construction and is shown in Figure 15. From the model test the ultimate strength of the actual structure could be predicted and also the general mode of failure.

Mancunian Way

Following the concept evolved for the Hammersmith Flyover, the Mancunian Way structure was developed. This structure, comprising many spans of 105 ft. with precast units of the type shown in Figure 16, is continuous and contains the prestressing tendons only in the webs of the precast units. The diffusion of this prestress through the unit, particularly in the flanges, is indeterminate and therefore the effectiveness of the flange in the structural action is unknown. A 1/12 scale model ([7]) (Figure 17) was therefore built to study this problem and many others. In fact all the essential design information was provided by the model test and of particular importance was the result that in situ concrete was un-necessary to stiffen the projecting concrete flange.

Western Avenue Extension

With the increasing demands of traffic, elevated roads having six traffic lanes were required particularly on the access routes to London. Part of the Western Avenue Extension comprises a spine beam structure, precast in sections, having spans of 208 ft. and a width of 94 ft. with each unit weighing some 75 tons. Part of the actual construction is shown in Figure 18; this gives some idea of the magnitude of the structure. In modelling this structure, a perspex slice was first used to study the stresses in an individual unit caused by the defined geometry of prestress. Then a 1/12 scale model in micro-concrete was built from units of the type shown in Figure 19; the finished model is shown under test in Figure 20.

These model tests of developments in the approach to urban motorway structures are paving the way to the codification of design procedures for them and ensuring the maximum economy is achieved.

Conclusions

I hope that the examples I have discussed, and others illustrated in my lecture, will have shown how, in a sense, model analysis and testing has truly come of age. With this technique the designer can conceive and build imaginative structures without being handicapped by his, or others, mathematical ability. Although I have concentrated on major structures, the use of model analysis and testing for the more simple, frequently occurring structures, offers considerable scope for improving the understanding of their behaviour, improving the designs and, not least, improving their economy. I believe that this technique will gain increasing acceptance as a design tool in its own right and should be considered equally with the other tools available to the responsible designer.

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2. Model Testing. Proceedings of a one day meeting held on 17th March, 1964, London. Cement and Concrete Association.

3. **Base, G. D.** Tests on a perspex model anticlastic roof of lattice construction.
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4. **Jones, L. L.** and **Base, G. D.** Test on a one-twelfth scale model of the dome shell roof for Smithfield Poultry Market.
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5. **Rowe, R. E.** Modelling of Shells—Co-report on Theme II 'Role of research in the design of shells'.
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6. **Rowe, R. E.** Discussion on "The Hammersmith Flyover" by Sir Joseph Rawlinson, P. F. Stott and C. P. Wroth.
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7. **Somerville, G. Roll F,** and **Caldwell J. A. D.** Tests on a one-twelfth scale model of the Mancunian Way Technical Report. TRA/394, December 1965. Cement and Concrete Association.

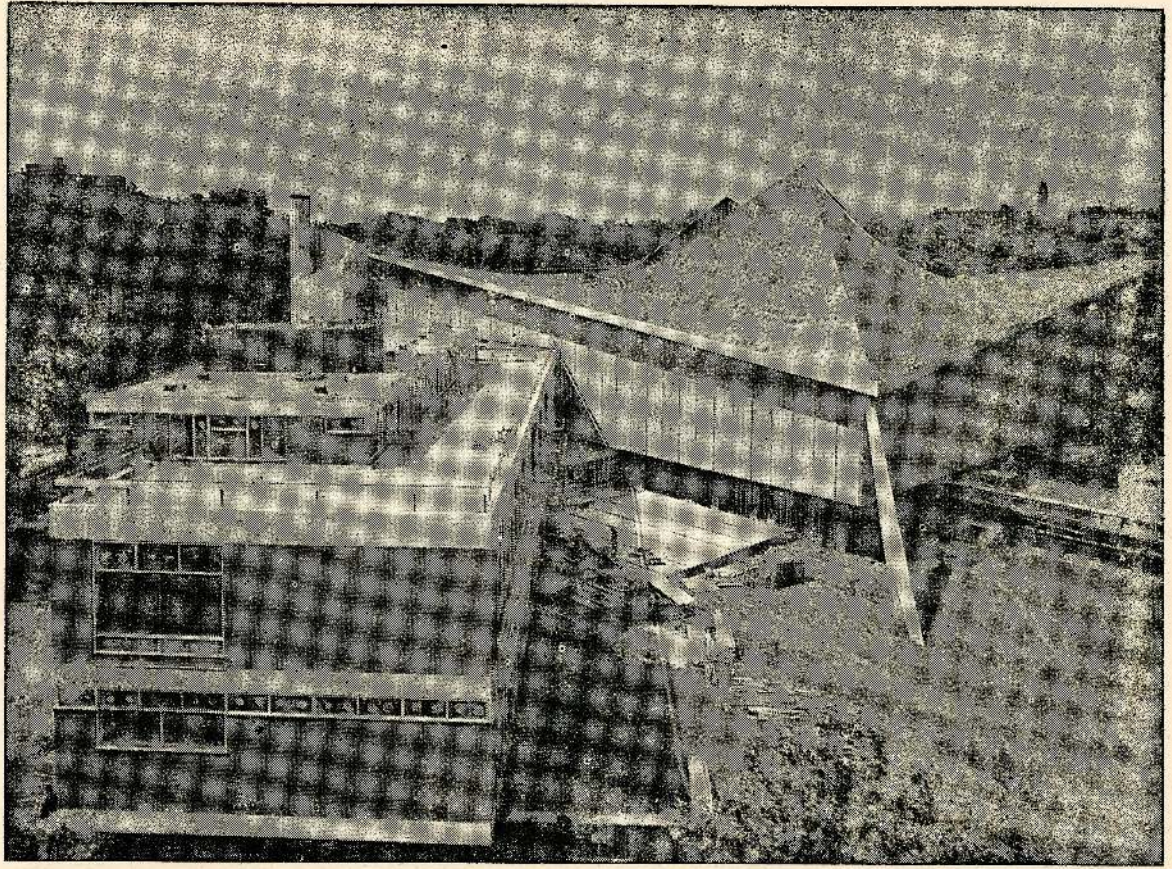


Fig. 1
Commonwealth Institute

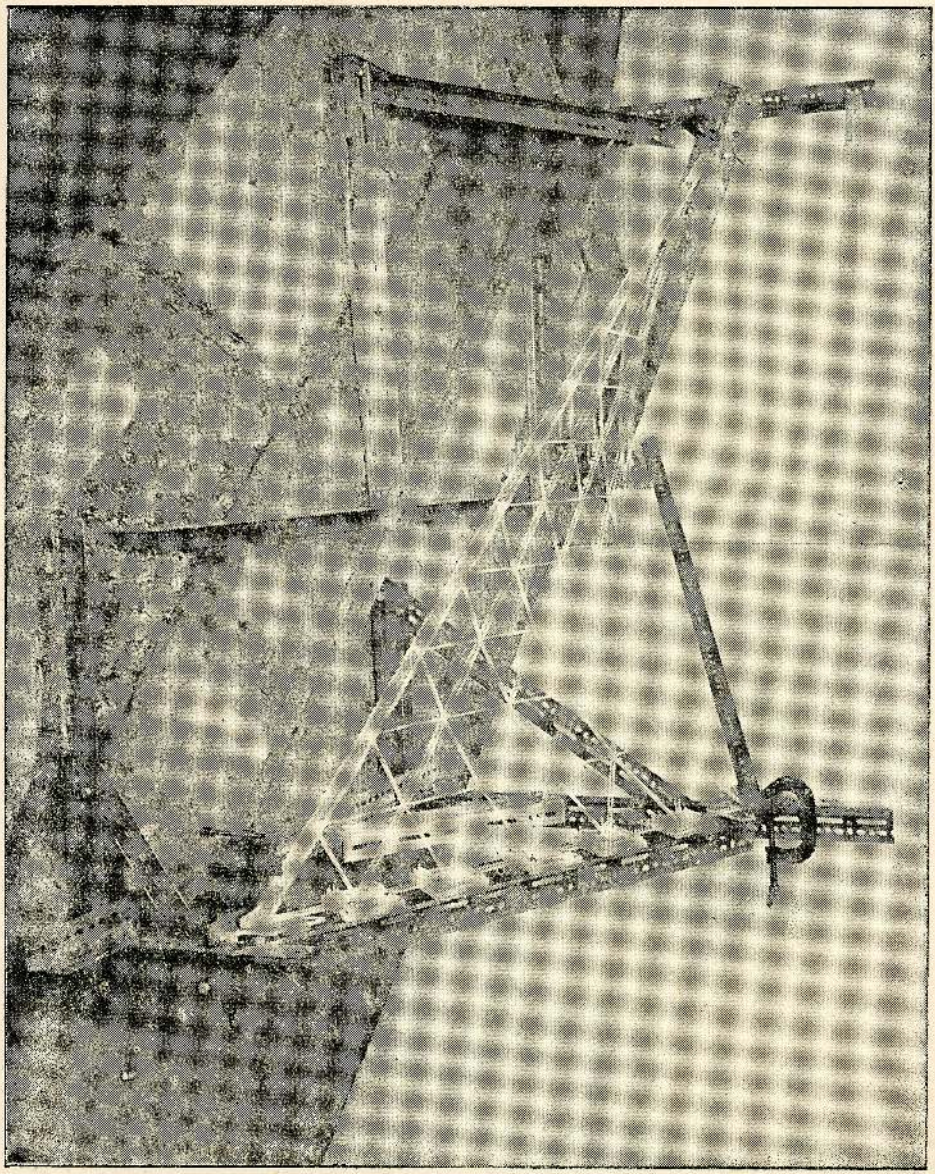


Fig. 2.
Model of roof section of Commonwealth Institute

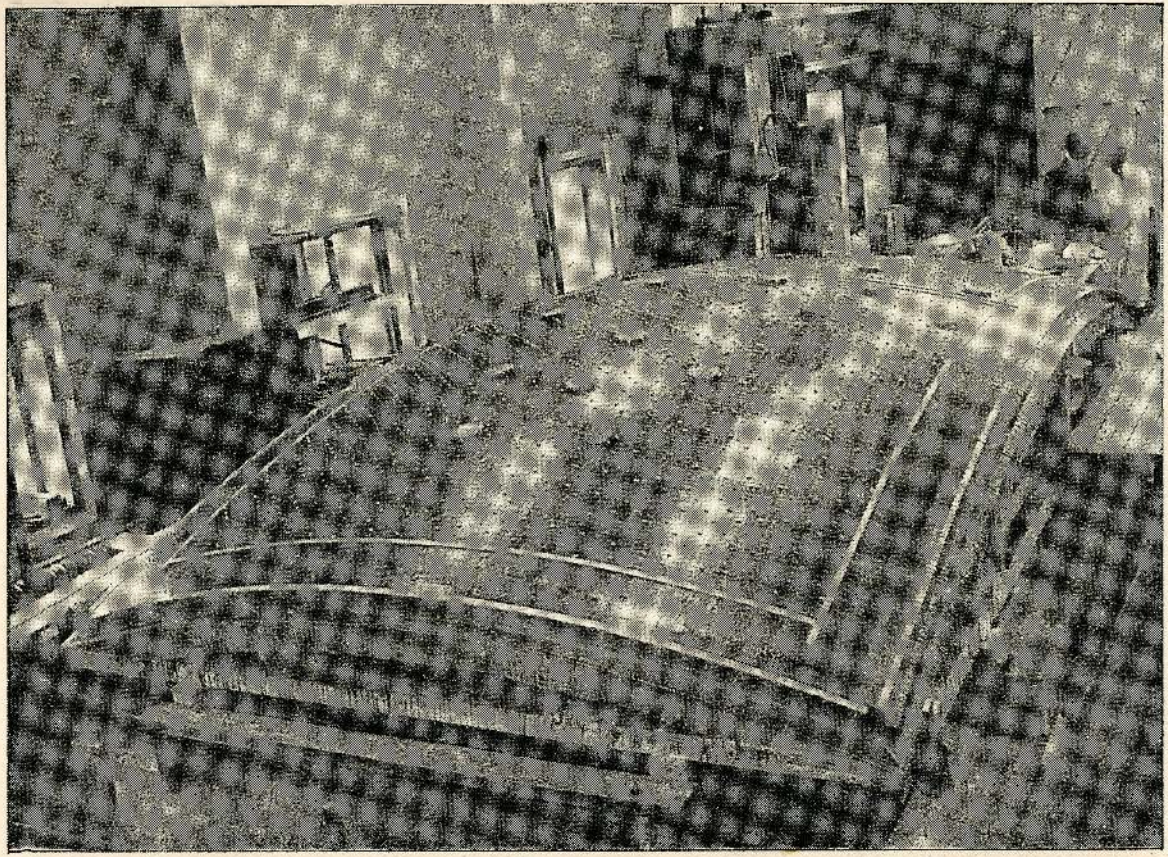


Fig. 3.
Shuttering for Smithfield model

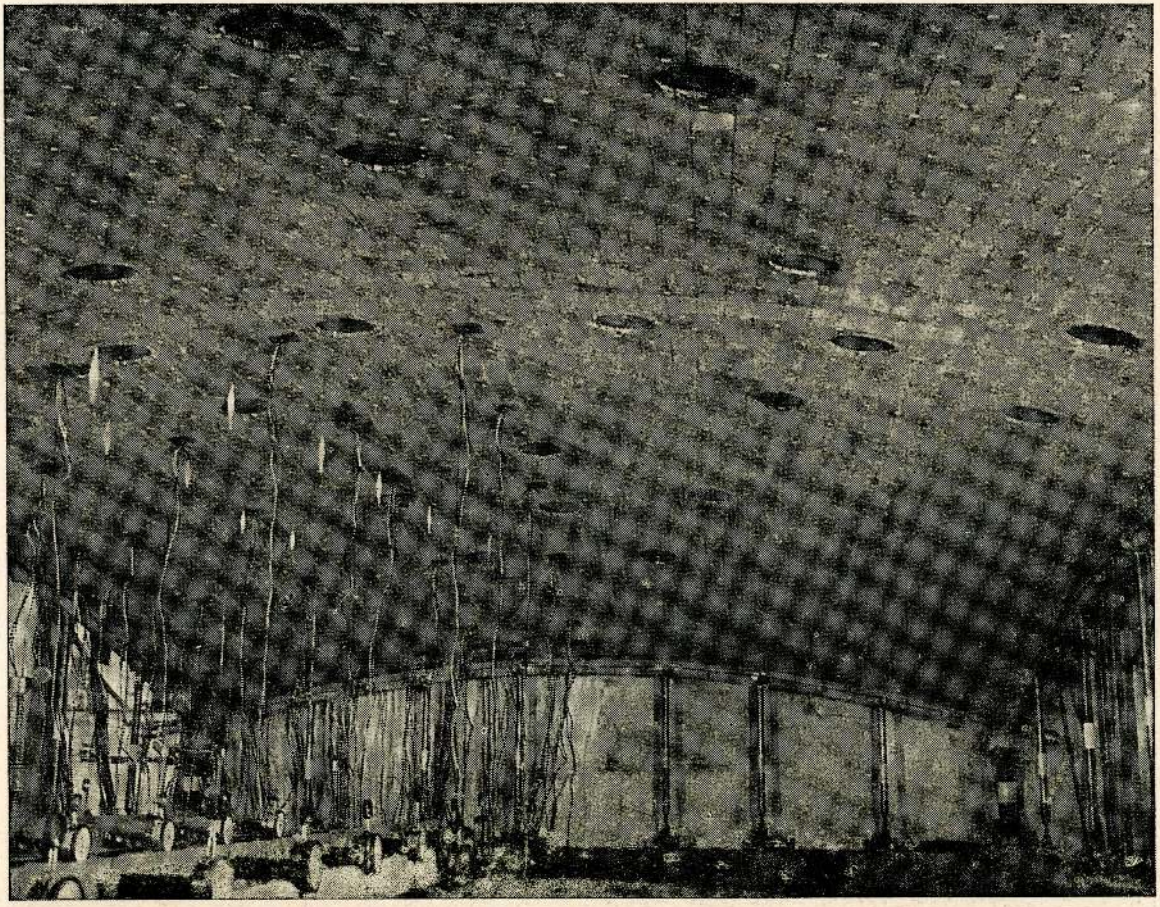


Fig. 4. (a)
Soffit of model shell

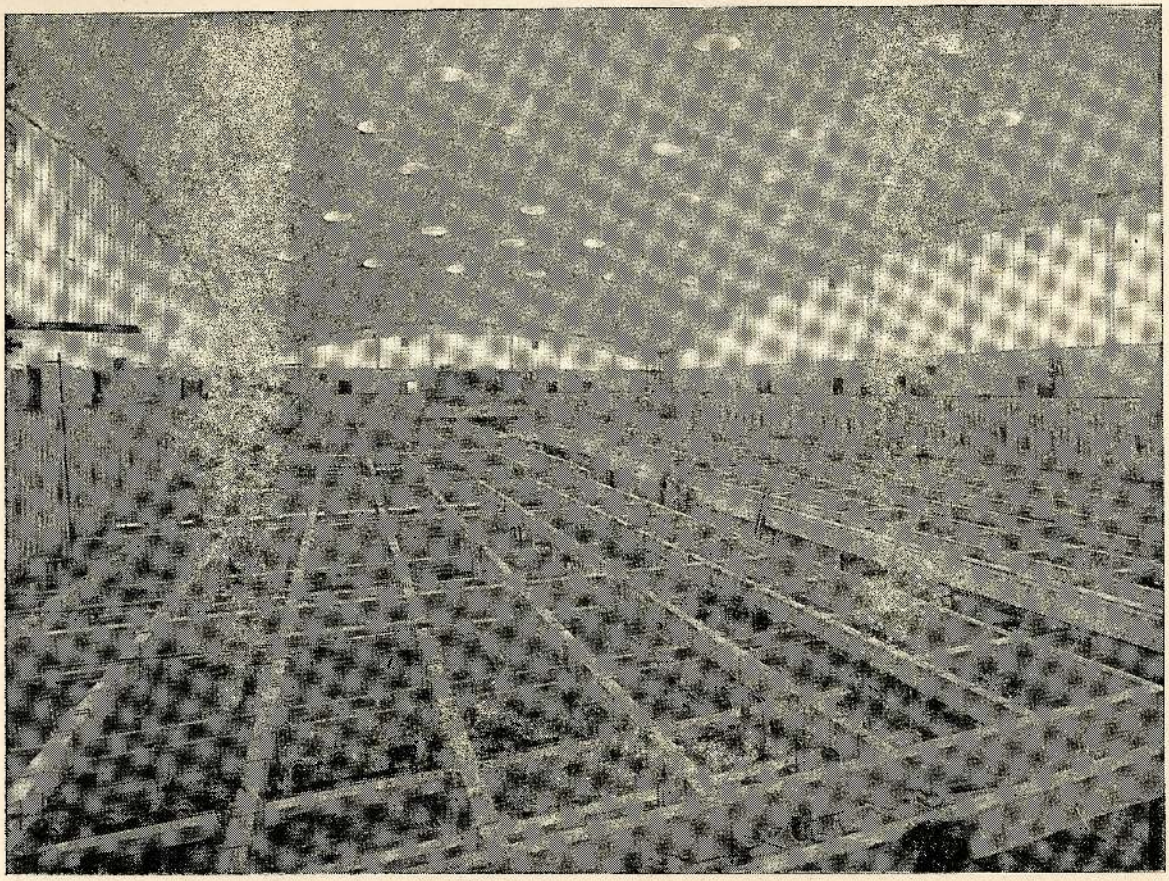


Fig. 4 (b)
Interior of Smithfield Poultry Market

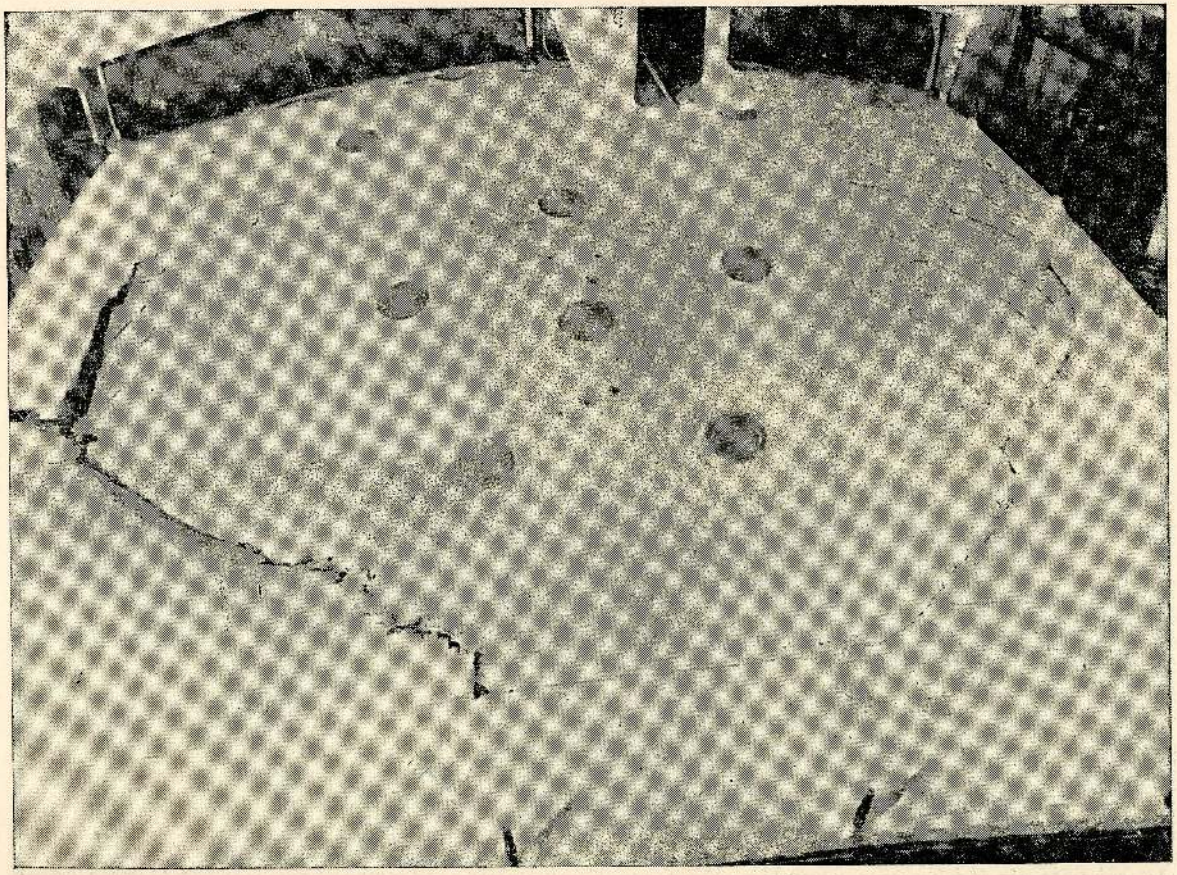


Fig. 5.
Buckling failure obtained on model

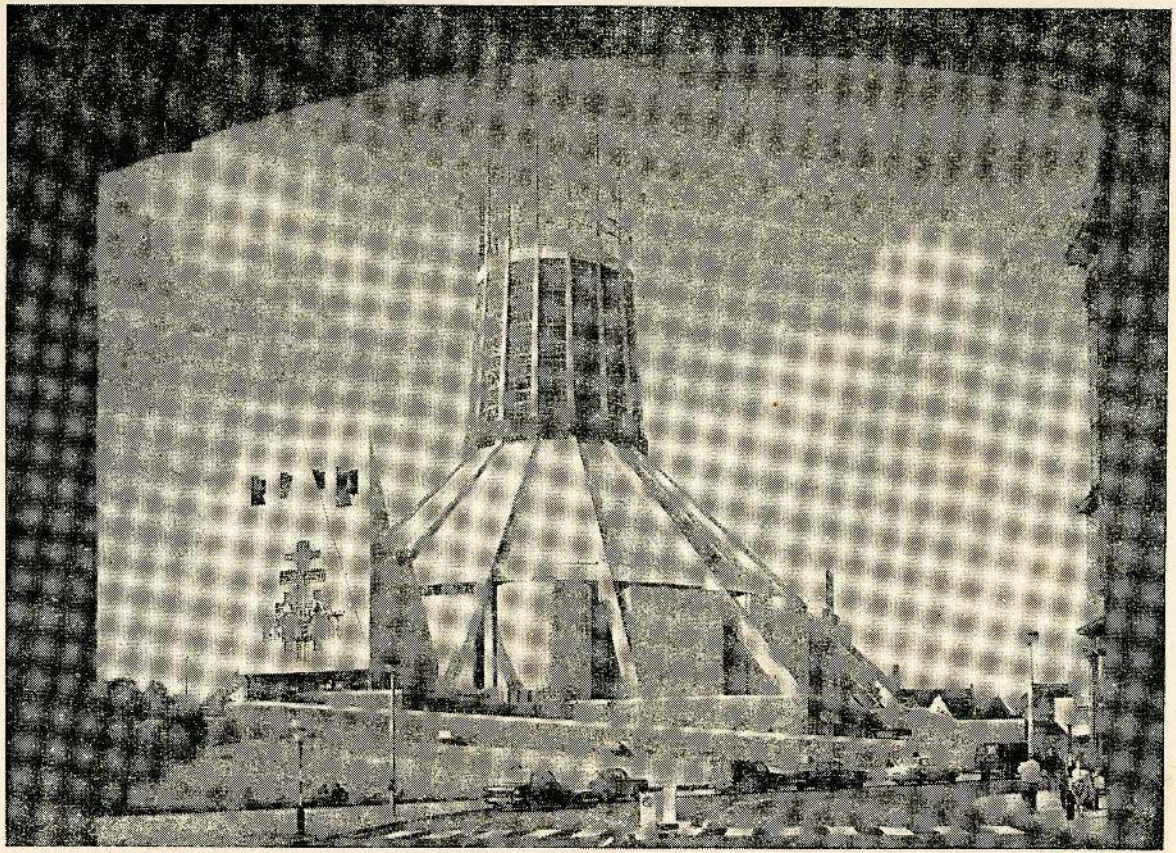


Fig. 6.
Liverpool Cathedral

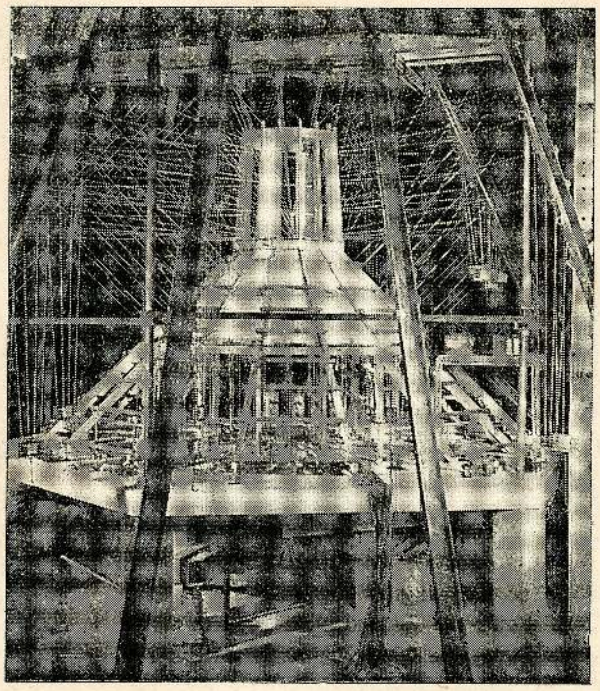


Fig. 7.
Model of Liverpool Cathedral

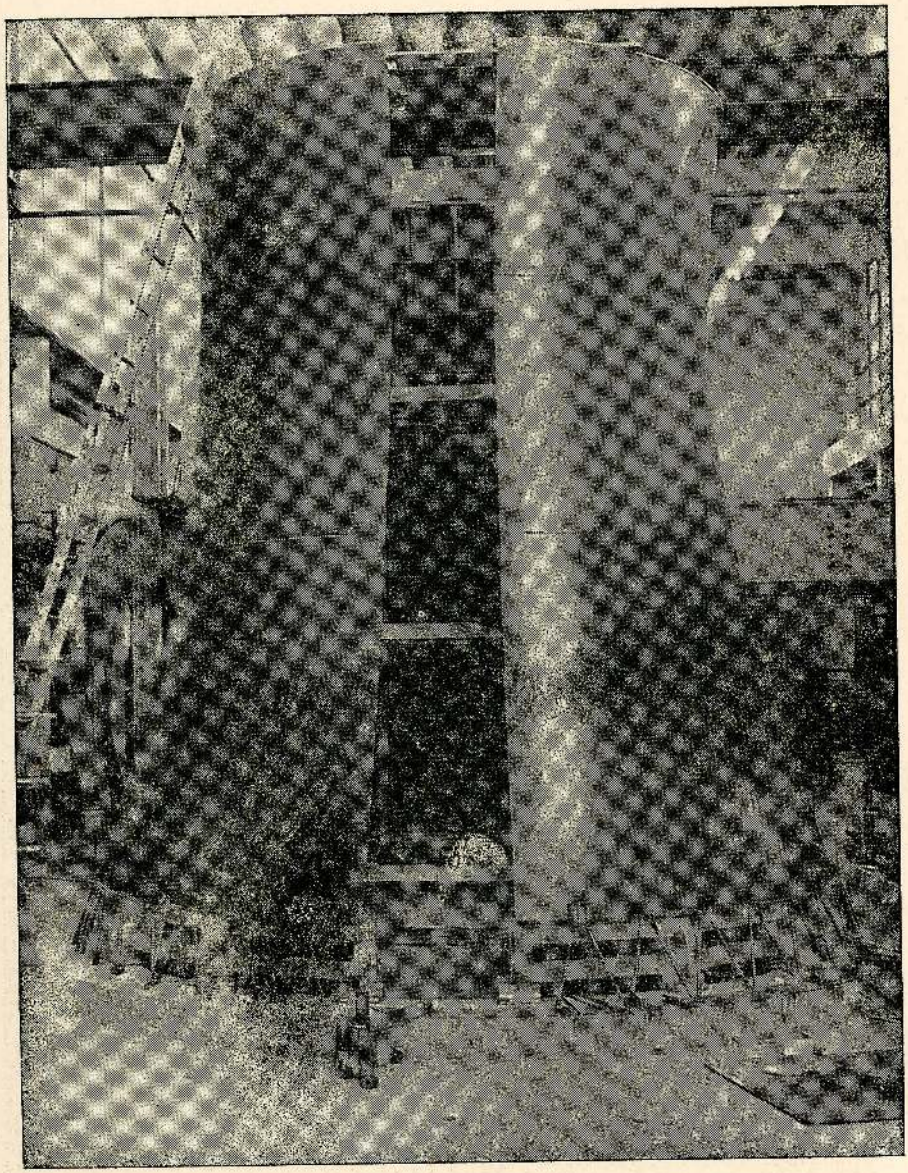


Fig. 8.
Shuttering for cooling tower model

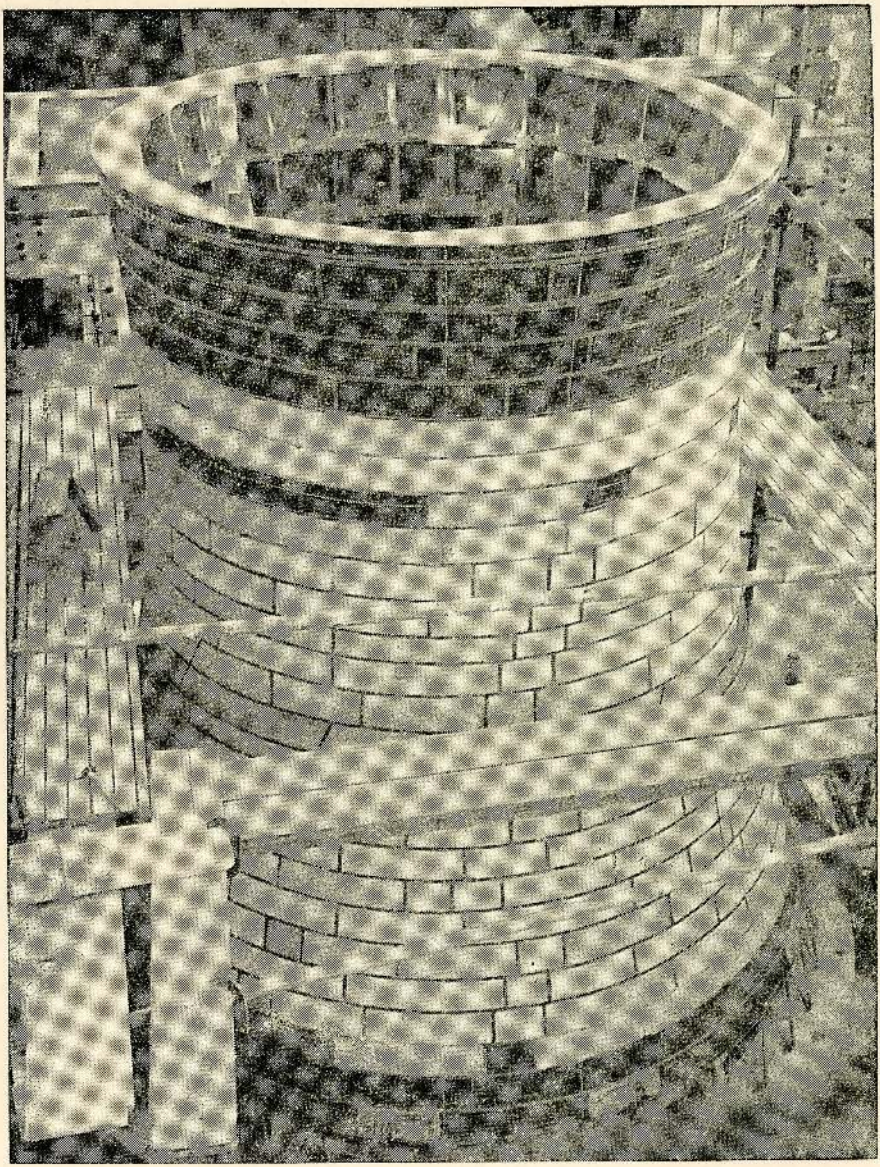


Fig. 9.
Construction in progress

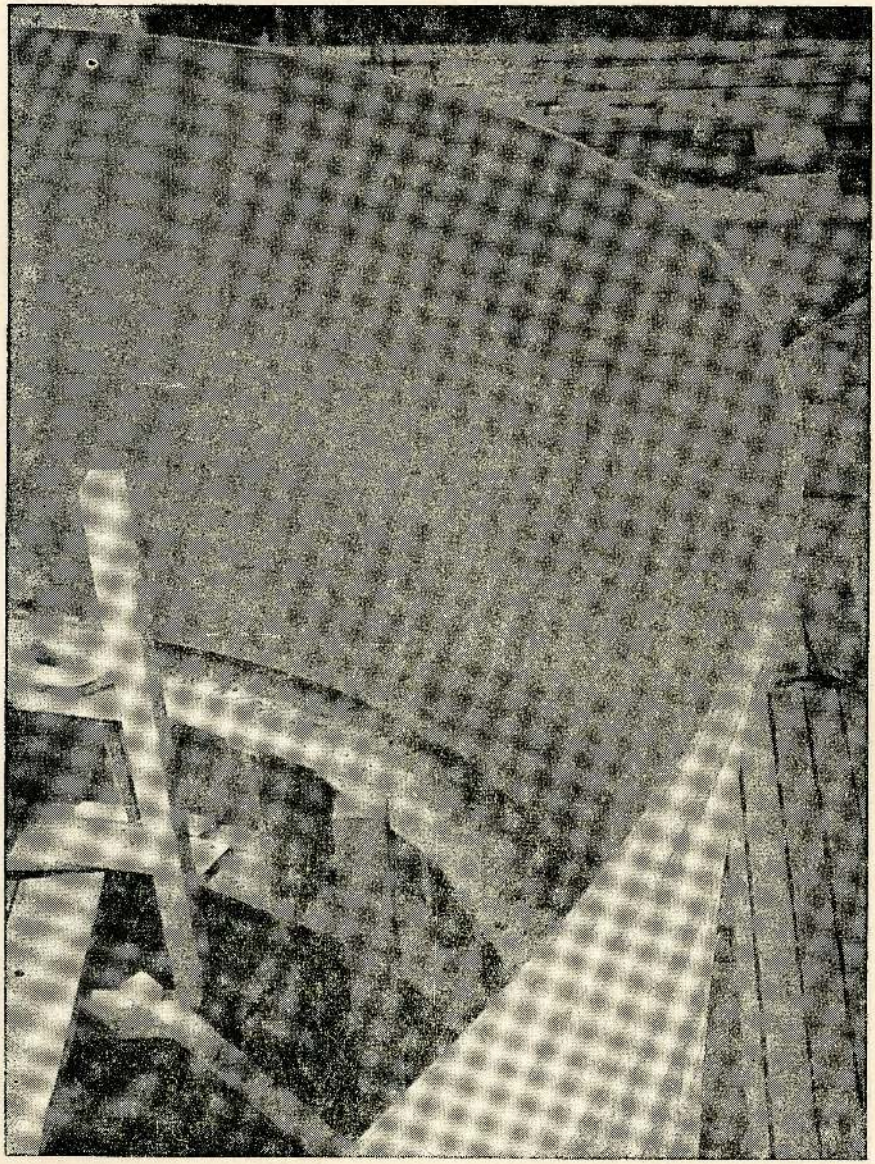


Fig. 10
Interior of model with some of shuttering removed

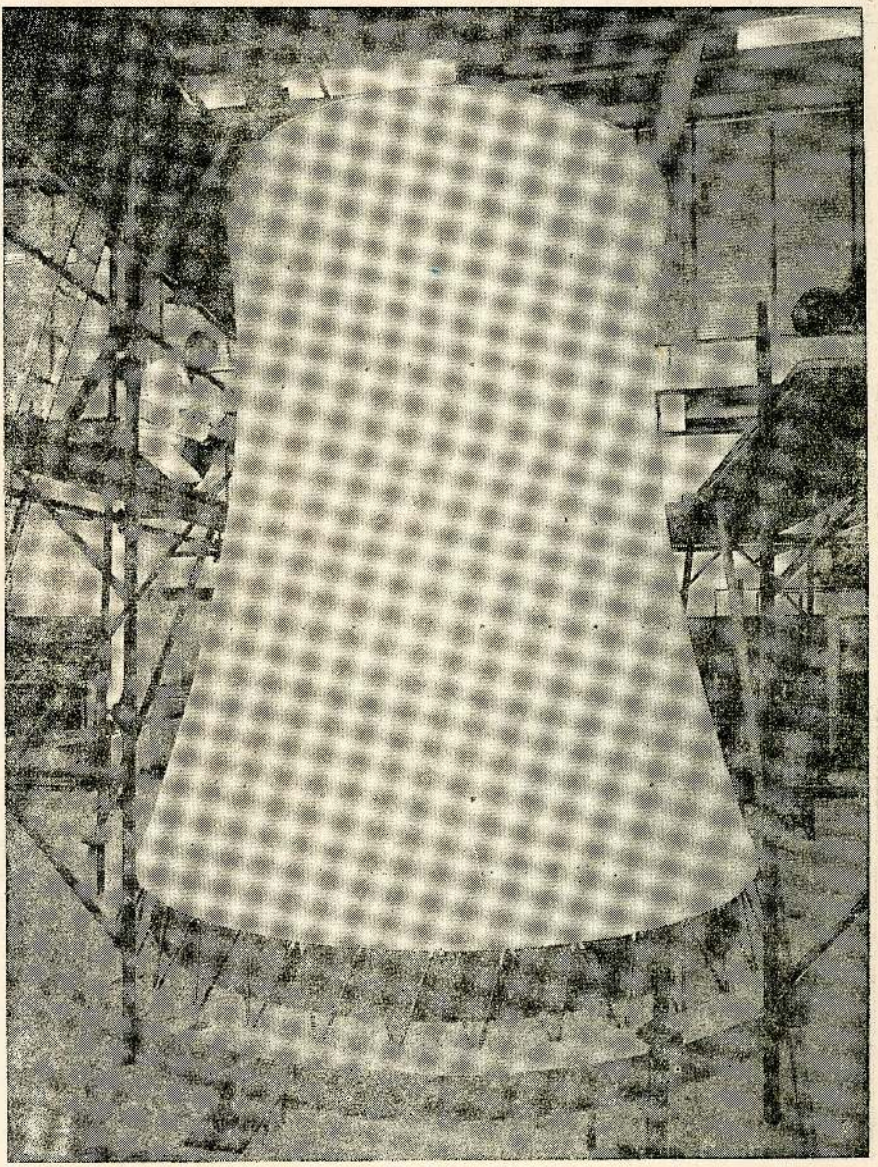


Fig. 11.
Completed model cooling tower

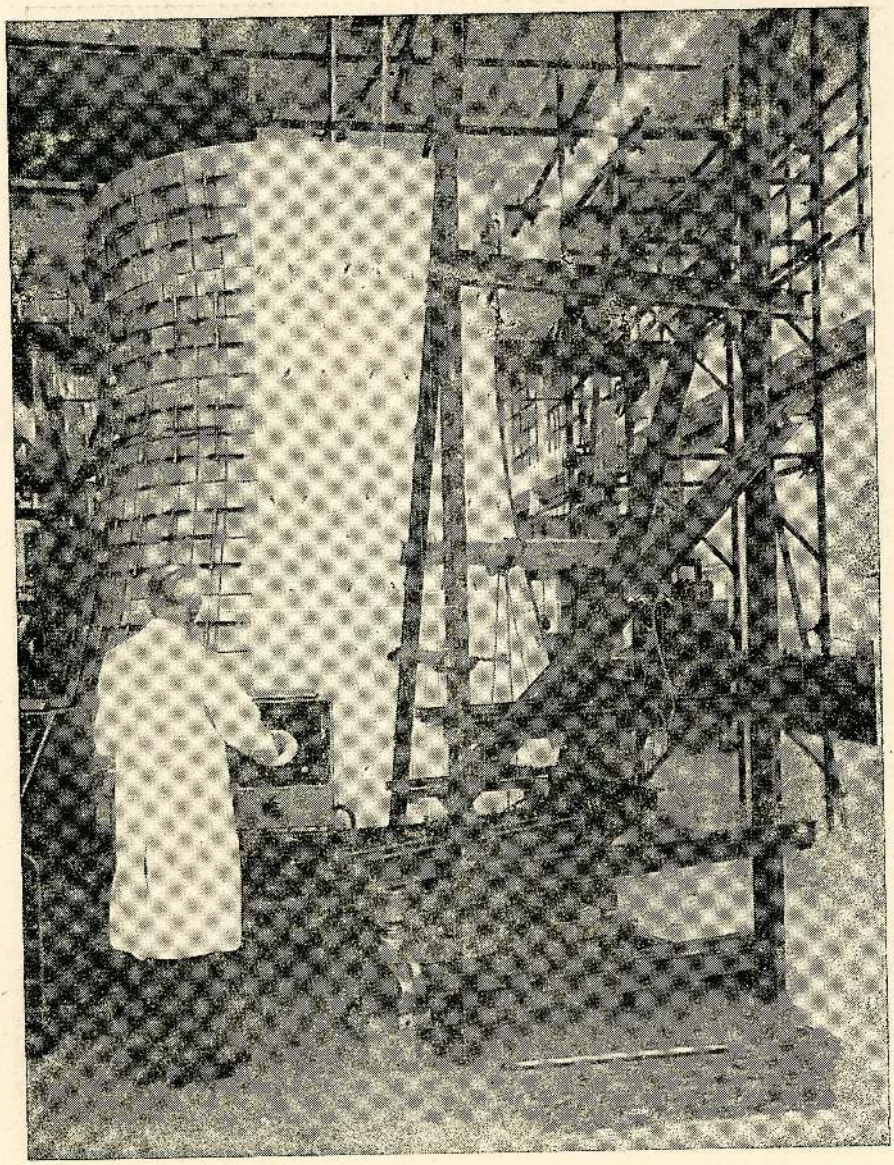


Fig. 12.
Wind pressure loading rig on model

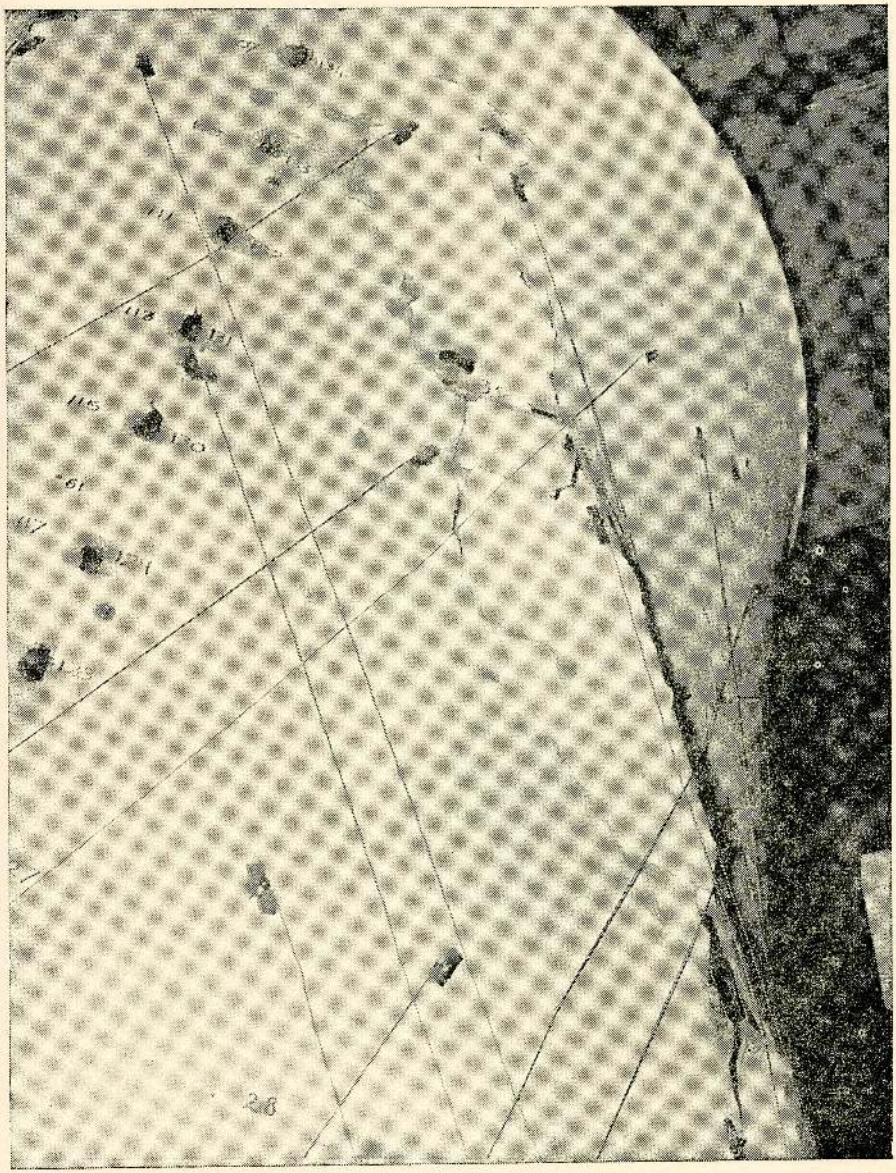


Fig. 13.
Final failure mode of model tower

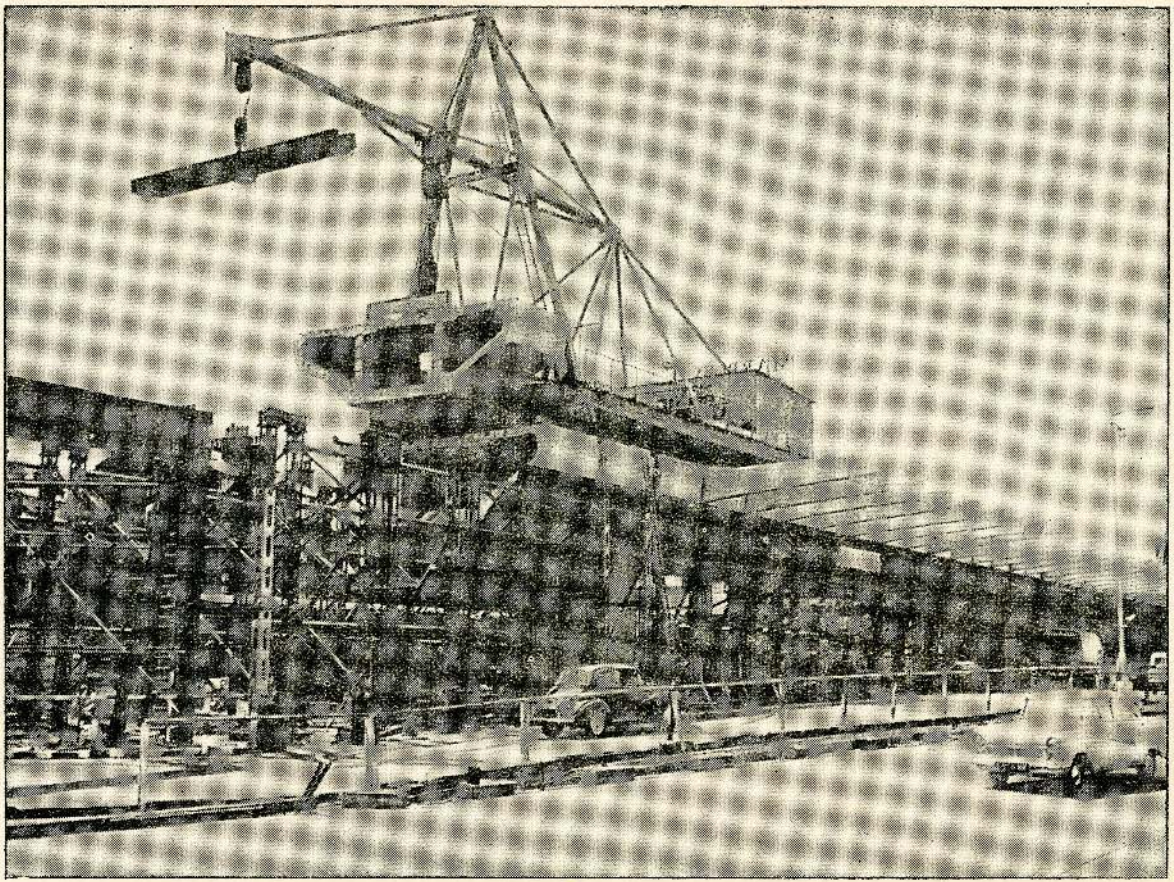


Fig. 14.
Hammersmith Flyover

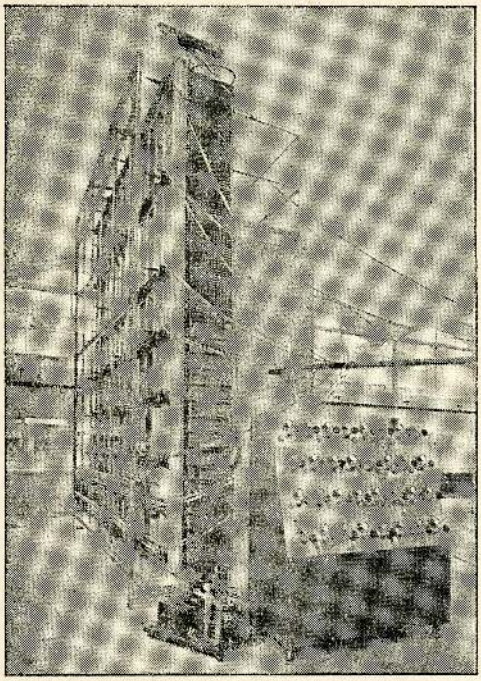


Fig. 15.
Model of part of Hammersmith Flyover

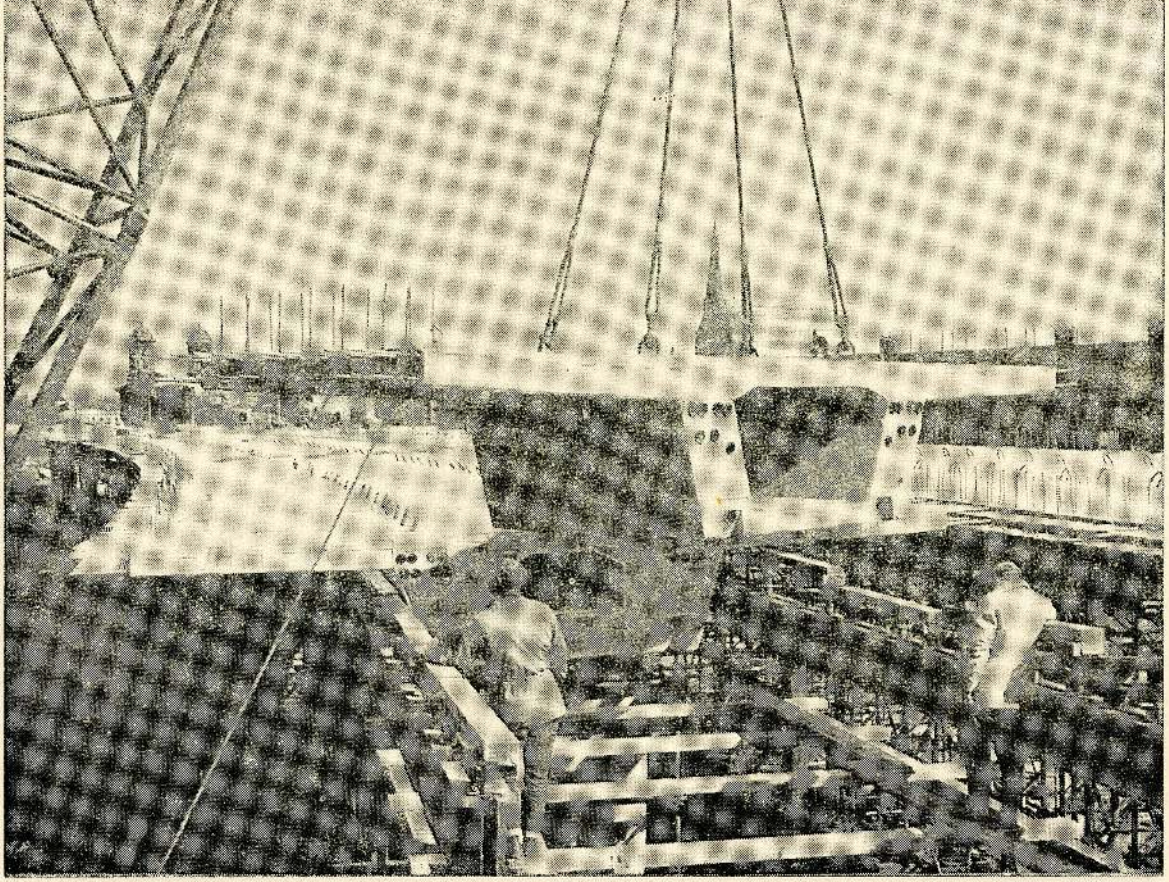


Fig. 16.
Mancunian Way

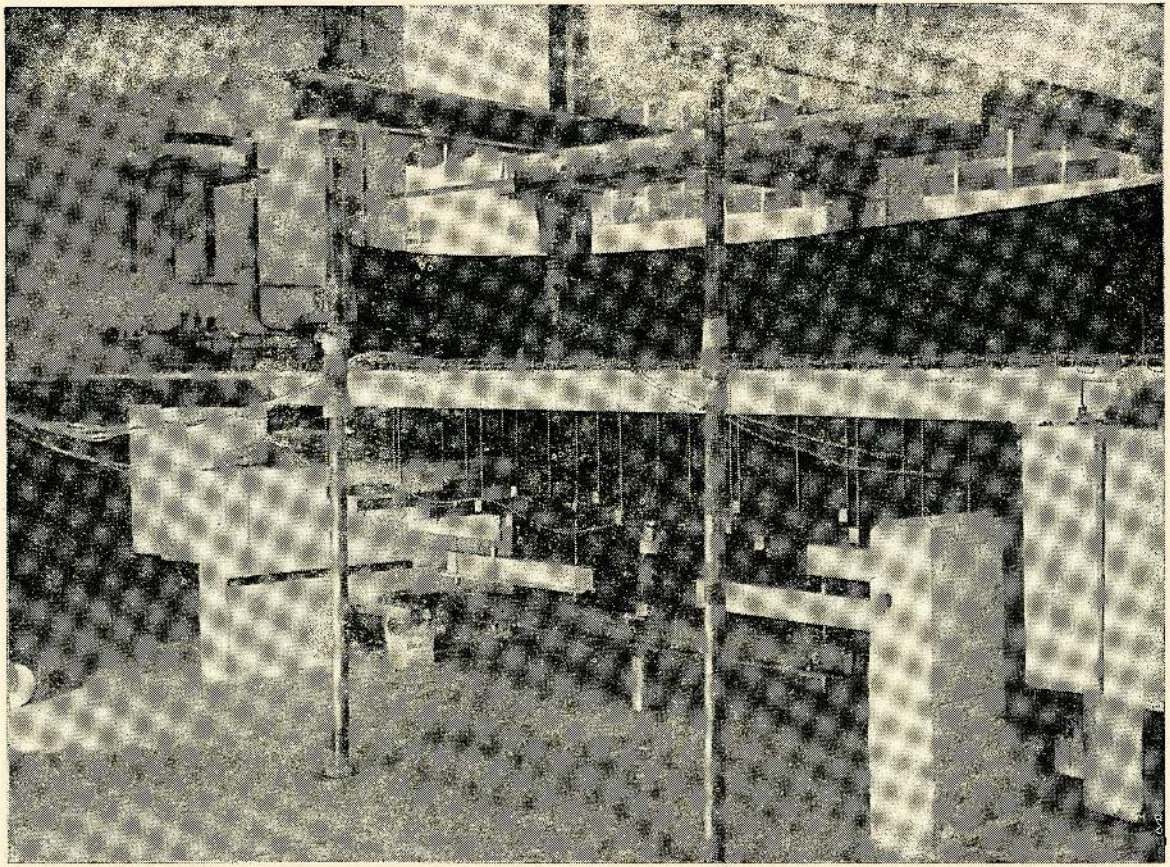


Fig. 17
Mancunian Way Model under test

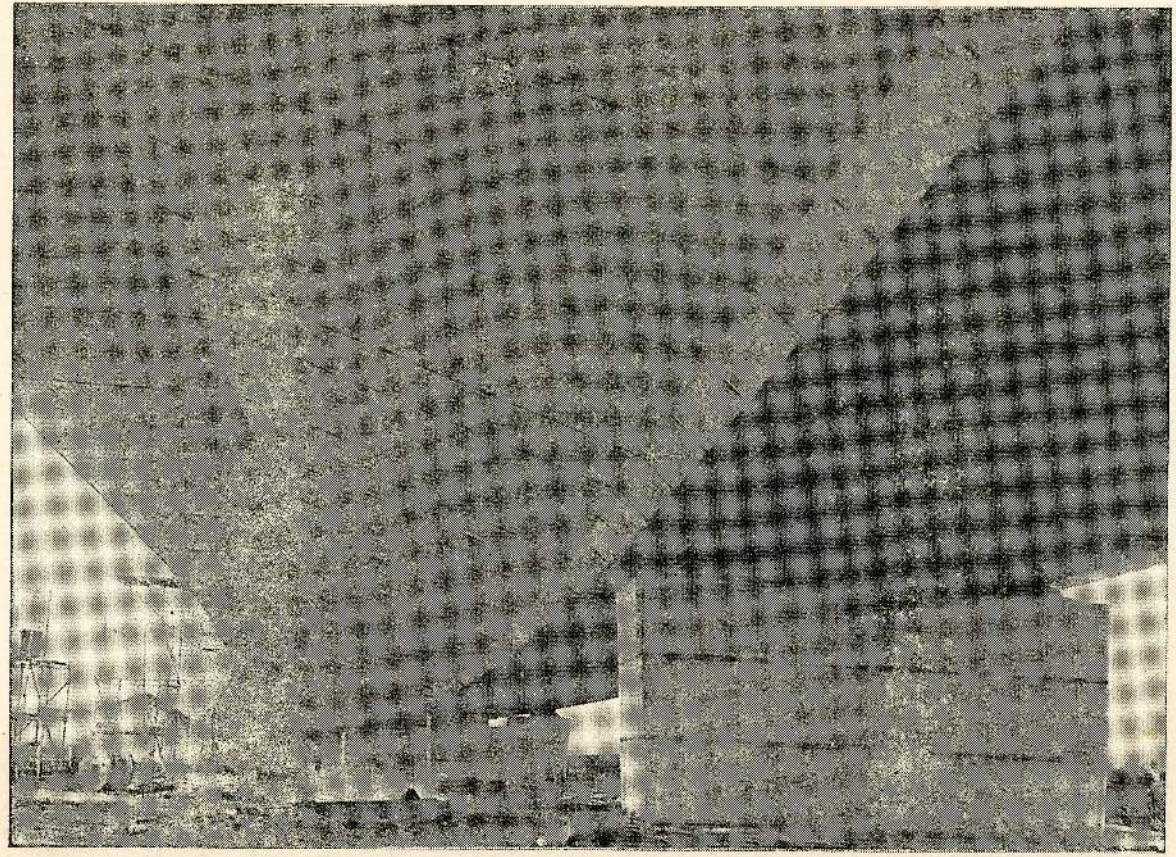


Fig. 18.
Construction of Western Avenue Extension

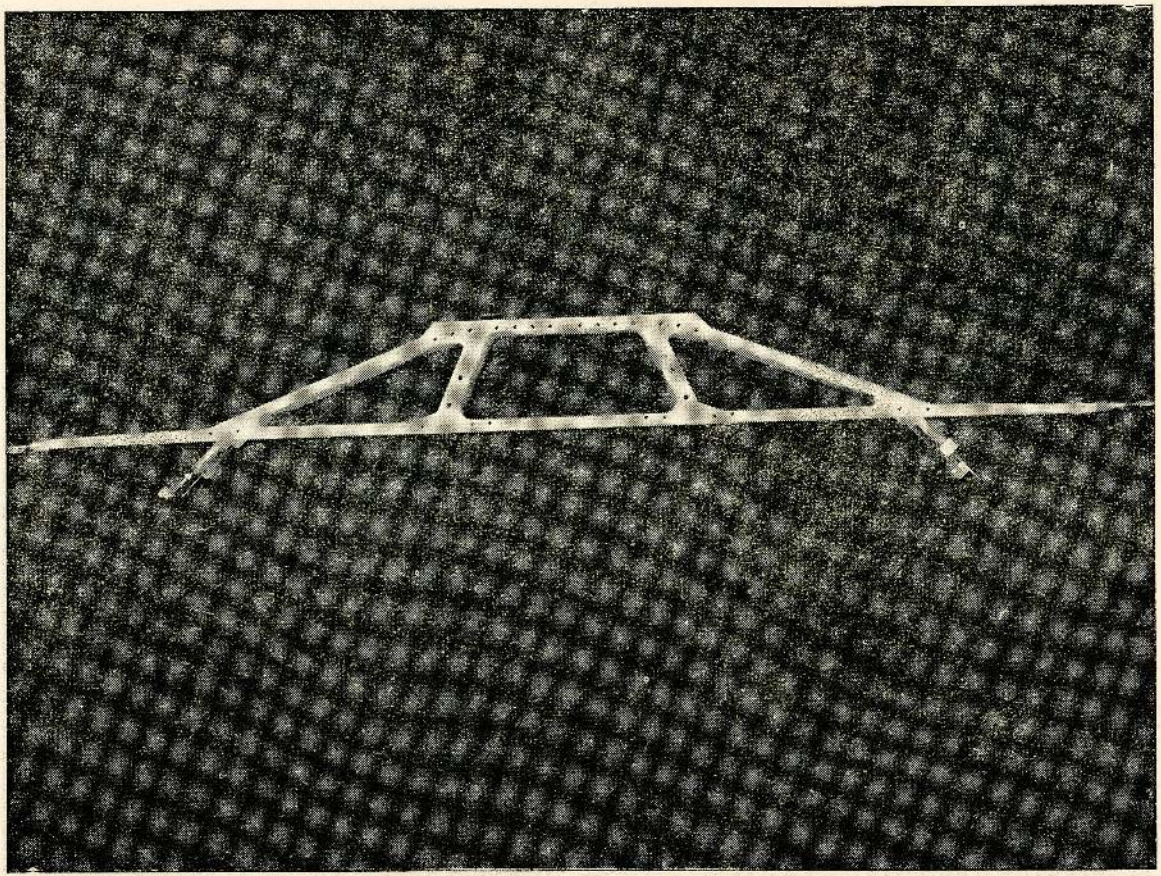


Fig. 19
Model units for Western Avenue Model

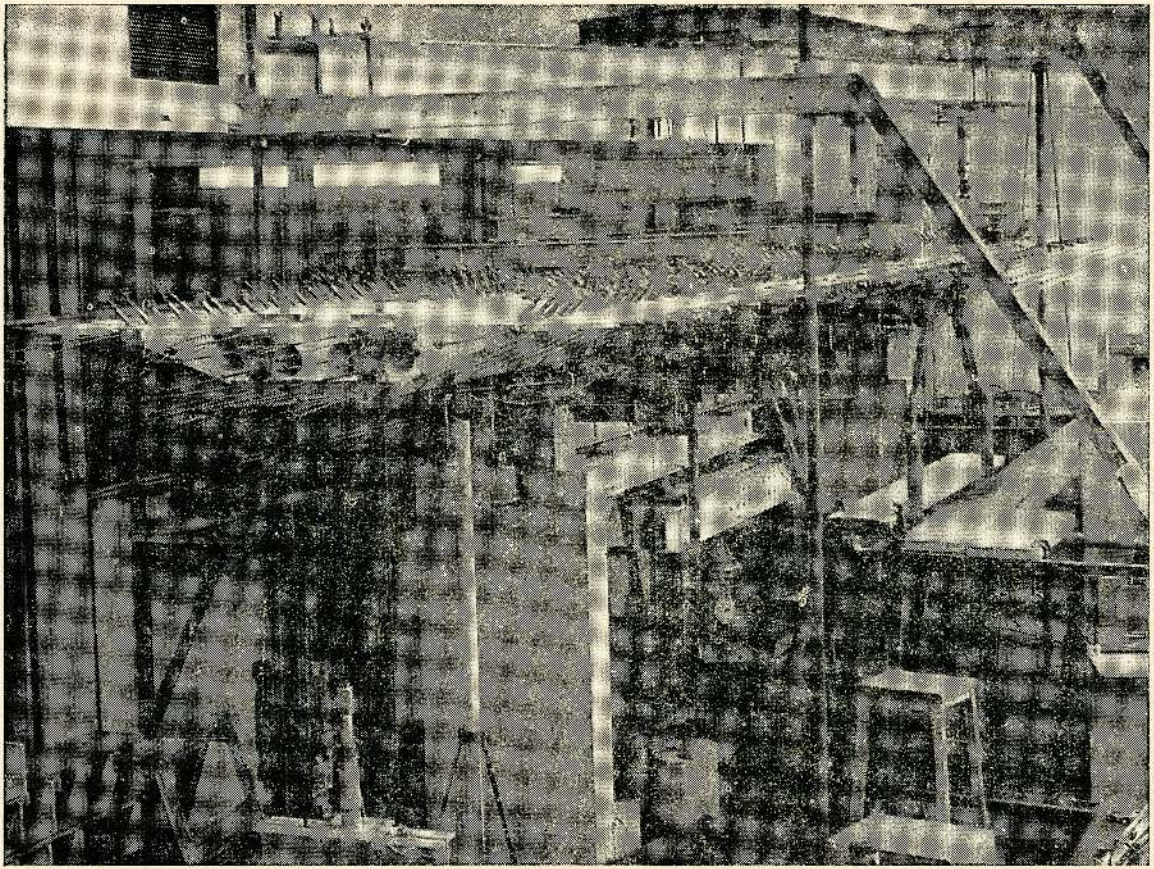


Fig. 20.
Completed Western Avenue Model under test

THE INSTITUTION OF ENGINEERS, CEYLON

Vote of Thanks to Dr. R. E. Rowe

By Mr. A. N. S. Kulasinghe — President

In the absence of any further questions, I wish to thank Dr. Rowe for the excellent lecture he has given us. We are very happy, indeed that Dr. Rowe was able to come all the way to give this lecture, and I am sure the 8,000 miles he had to travel is fully worth, considering the results at this end. I am sure, our young engineers, particularly those who are engaged in concrete research, would be stimulated to go further in this direction. I would request you to give him our thanks in the usual manner.

THE INSTITUTION OF ENGINEERS, CEYLON

DISCUSSION ON PAPERS

ANNUAL CONFERENCE 1969

THE INSTITUTION OF ENGINEERS, CEYLON

Some Preliminary Investigations into the Manufacture of Clay Purlins

by Dr. A. M. N. Amarakone, B. Sc. Eng. (Hons.) D.I.C.,
M.Sc. (Eng.) Lond., Ph.D. (Lond.), M.I.E. (Cey.)
Mr. W. M. Jayawardhane, B.Sc. (Eng.) Associate Member, I.E. (Cey.)
and
Mr. A. N. S. Kulasinghe, B.Sc. (Eng.) Hons. (Lond.), C.Eng.,
F.I.C.E., M.I.E. (India), F.I.Mech.E., F.I.E. (Cey.)

DISCUSSION

Introduction

Mr. Jayawardhane introducing the paper thanked the members of the Council of the Institution for accepting this paper to be presented at the annual sessions. He also thanked the co-authors of the paper for giving him the opportunity of addressing a learned gathering of professional men. He regretted the absence of Dr. A. M. N. Amarakone who took much pains in preparing the paper and who would have done a better presentation. Also he mentioned it was a rare coincidence that one has the chief of his employer organisation and the President of the Institution as a co-author in the paper presented to that institution.

Touching on the contents of the paper the speaker highlighted the main points. He very briefly touched upon the present day clay industry and the availability of suitable clay in the Island. He went on to mention that the State Engineering Corporation is engaged in investigations into the use of clay in the manufacture of structural members.

He next touched upon the difficulties encountered in evaluating the stress-strain curves for the material. He stated that an approximate relationship of the form $E = 1000 f_{max}$ could be expected from the behaviour of the many units tested.

The process of assembling prestressed clay purlins was then described.

The speaker then went on to the actual tests on assembled purlins and drew the attention of the audience to the observer load deflection characteristics, and creep curves.

The costs of the clay purlins were then compared with the equivalent concrete purlins.

He concluded by stating that his paper was essentially a preliminary investigation and much more work had to be done to evaluate the long term properties of the material and the units produced using it.

Comments by Members

Mr. Kulasinghe throwing open the subject for discussion touched upon the history of the subject which was kept out of the paper to cut down the length. He said that the clay industry is very old and fine clay products which are 2000 years old or even more are to be found. He also said that in spite of the fact that so many factories are turning out clay products the work done by the industrialists to improve the techniques of production and the quality of products is very little. He went on to say that if the industrialists concerned invested a very small percentage of their profits for Research and Development work, the clay industry would have been in a better position today. As an example he cited the Cement and Concrete laboratory of England which is financed by contributions from industrialists where the amount of research carried out is astonishingly large.

At the outset **Mr. M. G. Padhye,** Colombo Plan Expert, thanked the Chairman for permitting him to make some observations on the paper. He congratulated the authors for their efforts to make use of local materials. He, however, felt that when such materials are proposed to be used as standard materials, testing will be limited to about 2%, when it was necessary for the consumer to be sure that the sample was truly representative of the whole. For such conditions he wanted the inherent variability of the clay products to be kept in mind, of which the authors had made some mention.

To the six points mentioned by the authors, he wanted to add a few more. The first and the most important of all was about the uniformity of the quality of the materials, so that the sample was truly representative of the whole. The same applied to granulometry the clay percentage, numerological classification of the clay materials. Next came porosity and temperature and the duration of burning. According to his experience in India, the strength of the bricks varied from 500 p.s.i. to over 1000 p.s.i. and the porosity depended on the method of manufacture. The variation was evident from the graphs 3 and 7 even for purlins from the same quarry and manufactured under relatively close supervision. He felt that purlins manufactured in the country as a whole might show greater variation.

Referring to tests, Mr. Padhye felt that the clay bricks would not behave like an elastic material and that repetitive load tests need to be taken to ensure that the purlins behave in an elastic manner and do not show a permanent set. In respect of creep tests he felt that the tests would have to be done over longer periods of six months or

more or short period tests would not reveal the true creep characteristics. He expressed that the authors appeared to be aware of these limitations and desired that the further studies be reported in the next sessions of the Institution.

He concluded his comments by thanking the President and the members of the Institution for giving him an opportunity to place his views before them.

In replying to comments made by Mr. Padhye, Mr. Kulasinghe said that the variability of products is always kept in mind and experiments are in progress to eliminate this as far as possible. But he said that it will not be possible to eliminate all the variation because even in case of concrete where properties of the constituents are well known the variability has not been completely eliminated. As such he said that the use of this material will be limited only to such areas where it could be used safely with the knowledge already available. Also he mentioned that further research is being done on the use of clay as a material and also on structures built using this material.

Mr. Jayawardhane while thanking Mr. Padahye for the interesting comments he made, mentioned that as far as variability is concerned, even in a well organised production line a certain variability is unavoidable and there is always a consumer's risk and a producer's risk in the quality of the product being too high or too low.

In emphasising the need for more and more research on the subject he mentioned that as far back as 1952 recommendations were made to the government on setting up of a Clay Research Institute by one Dr. J. S. Hoskin who was invited to Ceylon to look into this problem. Even after seventeen years, he said that we still have the same problem. He confessed that not only as regards variation in quality but even in the fundamental properties more and more research has to be done.

Mr. V. C. de Silva said that he wished to make a few comments. One was that the President had under-stated the case when he said that there had been no progress in Ceylon's clay products for several centuries. He added that one feature in the life of this country that made him sad was the state of the brick industry. It could be generalised and said that most of the products turned out in this country from the island's raw materials gave cause for sadness. A product of which this country can be proud is a rarity indeed.

Mr. de Silva added that when he was in China about three years ago, he visited two places where bricks were made. Plenty of know-how went into the preparation of the clay and the burning was done in kilns constructed on the chamber principle. Bricks of the highest

quality were produced at a cost of 14 Yuans which was less than Rs. 28/- per thousand ex works. The Director of one of those factories was proud of the fact that he was mechanising every possible process. When Mr. de Silva asked him whether with a population of over seven hundred million that would not create unemployment, he explained that they had more important work for every pair of hands released by mechanisation.

Continuing, Mr. de Silva said that he recently happened to come across a catalogue issued by a Japanese manufacturer of China-ware. Although the firm had very small beginnings, the aim of the founders was "to convert the soil of Japan into foreign gold". The foreign exchange earned for Japan by Noritake-ware today was probably more than the founders of the firm ever imagined.

Mr. de Silva also said that he would like to know from the learned author the sizes of timber purlins of equivalent strength to the clay purlins and the comparative cost of such purlins. While on the subject of timber, he said that he would like to relate what a Director of a timber factory in China told him. Though China was very rich in timber, they did not believe in wasting it. He stated that nothing was wasted from any log that came into the factory. One of the most important aspects of the place was that as soon as the timber was sawn, it was placed in drying kilns. He added that he would like to see drying kilns established on an extensive scale in Ceylon, because if the island's local timber was kiln dried, the need to import any foreign timber was not necessary. The money sent out on imported timber was an unnecessary drain on the island's resources.

Replying to the comments made by Mr. V. C. de Silva, Mr. Kulasinghe said that although our bricks are poor in quality, they could be sold because it was good enough for certain purposes. But if better use is to be made of this product better attention has to be paid to the subject.

He also said that Mr. Silva's comments on timber were not irrelevant because attempts are being made to replace timber with clay.

Mr. **A. S. de Silva** expressed his thanks to the author for the paper he had presented. He had mentioned that clay bricks were manufactured in various parts of Ceylon. He asked the author whether he could give the composition of the clay he had used in forming that test. It was known that in the villages clay was used. There was clay in Mannar, the Southern, Northern and Central Provinces. It would be of interest to the House to find out what the author had used in those purlins. In the villages when bricks were turned out villagers used a sprinkling of sand. He wished to know whether it had any structural value.

Mr. Jayawardhane replying Mr. A. S. de Silva said that he could not give the chemical composition of clay, but the clay used was that which is used for making ordinary flat tiles. Continuing on the question of sprinkling sand Mr. Jayawardhane said that it is done to reduce shrinkage, and cracking, but the porosity increases with the sand content.

Mr. Kulasinghe speaking on Mr. Silva's comments said that with a little variation in technology most of the clay found in Ceylon could be made use of. While very good clay is found in certain parts of the island certain clay deposits are bad he said. Anuradhapura clay used in the experiments he said is probably the worst. Although no extensive research has been done in this direction he said that with the knowledge already available, much progress could be made in using this material.

Mr. Jayawardhane in answering Mr. Silva's question on the cost of equivalent timber sections, said that for a 10 ft. span a section of 5" x 3" is used and the approximate cost is Rs. 1/50—2/00 per linear foot. For a span of 15 ft. the section used is 6" x 4" and the price is about Rs. 2/50 per linear foot. These prices he said are for Class I timber.

Mr. C. Kangatheran stated that the State Engineering Corporation and in particular, Mr. Kulasinghe should be congratulated for having made further progress in making use of indigenous raw materials which have not yet been fully exploited.

Some factors which contribute largely to the quality of the final clay product would be the type of clay, moisture content at the point of extrusion and the firing conditions in the Kiln. Hence it would be of interest to know the extent of quality control exercised at the factory in the processing of the clay and the firing conditions in the Kiln.

He further said that type of clay and the percentage of clay fraction (as characterised by the Plasticity Index) would effect the strength of the clay product and the shrinkage. The moisture content variations would also cause varying amount of shrinkage. Hence it was felt that the plasticity index might be a very useful controlling factor if the moisture content and the firing conditions would be controlled.

In reply to Mr. C. Kangatheran's comments on classification and properties of clay Mr. Kulasinghe said that what the authors have tried is not to effect a classification of Ceylon clays because it is too big a job for them. What has been tried is to produce structural components from clay which is used for making standard clay products.

Further he said that the importance of studying deep into the material is not neglected, but only a secondary importance is attached to it as against actual production. But he said the authors are not engaged in analysing Ceylon clays from a soil mechanic's angle.

Mr. K. Kathirgaman said that clay was the term used in the local building industry for a widely varying class of materials without much regard to the engineering properties. For a material used in testing and fabrication of special components it would be necessary to ascertain its chemical and engineering properties such as Atterberg Limits, gradation size, permeability, clay mineral etc. to control or select suitable clays based on laboratory tests.

Continuing, Mr. Kathirgaman said that the quality of building bricks in the country was very poor. There was considerable variation both in the strength and in the sizes. That might be attributed to poor control on the quality of clay and primitive methods of manufacture. As a result users of brick were involved in extra expenditure.

He therefore, suggested that detailed tests be carried out on the various clays and the most suitable were used. Periodical tests might be carried out to ensure uniformity of the material. No mention had been made in the paper regarding the properties of the clay used and further, he said, that it would be interesting if the authors furnished any available properties of the clays used in the production of purlins.

Mr. Jayawardhane referring to comments made by Mr. Kathirgaman on the quality of bricks said he admitted that the standard of the brick industry in Ceylon is very low and it is even a waste of resources. Steps have to be taken to develop the industry as a whole he said.

THE INSTITUTION OF ENGINEERS, CEYLON

Analysis and Design of a Flat Slab Floor for the C.G.R. Terminal

by Mr. A. D. White, B.Sc. (Eng.), D.C.T., M.Sc. (Eng.) Leeds, C. Eng. M.I.C.E., M.I. Struct. E., M.I.E. (Cey.)
and Mr. D. A. Jayasinghe, B.Sc. (Eng.), M.Sc. (Eng.) Leeds, C. Eng., M.I.C.E.

DISCUSSION

Introduction

Mr. White introducing the paper explained some of the terms used in the notation, in particular the partial derivative operators. Commenting on the use of yield-line analysis in general he stressed on the need to check the conditions under working load especially with regard to deflections. This he said was achieved by carrying out an elastic analysis using finite difference techniques and a model test done to check the deflections and the load factor against collapse.

The co-author, Mr. Jayasinghe explained briefly the method of finite difference analysis and the flow diagram on which the computer programme was based. He also commented on the main considerations in the construction and testing of a structural model.

Both authors wished to express their thanks to the staff of the Research and Development section of the State Engineering Corporation who made possible the testing of a relatively difficult model.

Comments by Members

Mr. A. N. S. Kulasinghe speaking from the chair, reminded the members of the value of model testing techniques as was pointed out in an earlier lecture by Dr. Rowe. He added that those techniques were first used in Ceylon at the Port Commission, for the analysis of problems that were not quite straight-forward.

In the problem investigated by the Authors, the boundary and support conditions were such that an exact analysis was extremely difficult and the nearest practical approach was a solution by yield-line analysis. A numierical approach too had to be made to understand the behaviour under elastic conditions. As this entailed a heavy volume of work, it was fortunate that the services of a computer were available to solve the simultaneous equations that were set up.

A model test was finally carried out to verify certain characteristics and to study the behaviour of the slab. Deflections were one of the chief characteristics studied. One of the advantages of such a test is that you can observe the performance of the structure during the various stages of testing, which is not so readily available from the analysis. This gives the designer a certain amount of confidence in what he has done and the construction engineer some idea of the precautions he has to take.

He further added that a justification for the use of a model was hardly necessary in the light of Dr. Rowe's remarks that it is time and money well spent. With these remarks he opened the subject for discussion.

Mr. K. Satgunasingam in contributing to the discussion requested the authors to describe the functional aspect of the building, and stated that the depth of slab adopted by the authors was 12" for a superload of 100 lbs/sq. ft. He said that the self weight of the slab alone was 150 lbs/sq. ft. and particularly in view of long spans considered in the design it would have been economical to have considered Hollow Tile Slab design where the self weight could have been reduced by 50%. An in situ hollow tile slab spanning between solid strips within the depth of slab appears feasible especially as a result of considerable reduction of the self weight of the slab. He commented that this type of slab was generally considered to be economical for the spans and the superloads adopted in the design. He however, felt that if the hollow tile floor design had to be adopted for the entire 1st floor slab, it might necessiate shifting of the corner columns to the edge of the slab to facilitate introduction of a strip or beam along the edge of the floor.

He wished to know if such type of floor slab was considered by the authors before they decided on flat-slab design. He queried the authors why the upstand ring beam was of varying depths.

Mr. D. L. O. Mendis while thanking the State Engineering Corporation for this model analysis wished to know the cost of testing the model as a pescentage of the total cost of the job. He also asked the author whether the method of construction of the model had any bearing on the proposed method of construction of the building.

Mr. J. P. Senaratne said that the Terminal Building was the new railway station that would come up on the MacCallum Road side of the Fort Railway Station. In future, all trains would start from this station.

The Department has found that the platform accommodation presently available was totally inadequate to deal with the services,

the Railway has to provide for the travelling public The ground floor of this building would house the Booking Office, the baggage area, berth booking office, the Station Superintendent and those offices needed to run the Station. The first floor would house the Restaurant; there would be a specially fitted up dining saloon which could be used even by non train travellers, barber saloon etc. The 2nd floor will house the Chief Security Officers. The 3rd floor will contain 20 double rooms, and retiring rooms. Above this and in the centre, to get ventilation there is a centre shaft running through, and the dome embedded in this concrete will bring in a certain amount of light through the dome into the centre void.

He hoped that he had been able to give the members a picture or an idea of the functional purposes of the building.

He also said that there will be lifts with all the mechanisms in the basement.

The State Engineering Corporation had almost completed the piles and some of the piles will go down about 100 feet. He hadded that it would cost about Rs. 1.2 million on the piling alone.

Mr. T. Sivaprakasapillai stated that the President's remark that this may be a "dull" subject, prompted him to take the opportunity to announce to the members present that the University was now prepared to take Research students and guide them in subjects which might appear dull at first sight, but were very important, very useful and very necessary for the progress of the human race. Training and Re-training from the lowest to the highest level was the only way to attain progress. He further said that the State Engineering Corporation had attracted some of the best graduates and the University has a nucleus of young highly qualified and enthusiastic staff to guide and train enthusiasts in research and also award Higher Degrees to the deserving researchers.

Mr. Kulasinghe in reply to Mr. Sivaprakasapillai said that he was only joking when he had referred to this subject as being dull and added that it was indeed an extremely interesting one to him.

He went on to say that model testing was not started by the S.E.C. or by the University but that it was carried out at the Port Commission making use of certain facilities available there, on structures which were difficult to design. The S.E.C. was now using apparatus which he had set up years ago when he had time to do research himself. As for the subject being dull, it depends on the attitude as an engineer has to the subject. Nothing more than Dr. Rowe's remarks the previous day was required to confirm this point as he is an

expert on the subject. He further added that there was scope for research not only in the university but facilities were available in the State Engineering Corporation too.

Dr. D. A. Gunasekera said that in the analysis of a flat slab the accurate representation of the boundary conditions is vital. He asked the authors whether they considered using 5-point finite difference formulae in representing the bending moments, especially at the boundaries. He added that in his experience a much greater accuracy in the solution could be obtained in using 5-point finite difference formulae. He further remarked that there was hardly any extra manual effort or an appreciable increase in computing time, in using the more refined finite difference formulae.

He also asked the authors whether they studied the convergence of the solution with respect to the grid size.

Author's Reply

The author in replying to Mr. Satgunasingam sketched a cross-section of the building and explained that the C.G.R. terminal is a 4 storeyed building and the slab with which the paper is concerned formed the 1st floor. It is at a height of about 15 feet from the ground floor. There are 3 separate floors circular in plan above the first floor which are quite straight-forward in design. These together with the dome, are supported by columns passing through the 1st floor slab. The first floor is to be used as kitchen and restaurant, the upper floors as rest rooms while the ground floor is to house the luggage rooms etc. Where floor loading is rather heavy. He requested Ms. Paul Senaratne of C.G.R. to elaborate on the accommodation provided.

Answering Mr. D. L. O. Mendis, the author said that in this particular instance, the client was charged the usual consultancy rates for the preparation of structural drawings and hence the client benefitted from such a test at no extra cost. Regarding the second point raised by him he said that as there was nothing revolutionary in the method of construction proposed, the model too was constructed in a similar fashion i.e. the slab was shuttered completely and poured in one continuous operation.

In reply to the second question raised by Mr. Satgunasingam the author said that the spans and cantilevers were too large to enable the use of hollow slab construction. The architect required a cantilever of approx 18 ft. span at the corners and insisted on the columns being where they are. He also insisted on a flat soffit with a shuttered finish. The only solution possible under the circumstances was a R.C. slab poured in-situ.

Mr. A. N. S. Kulasinghe wished to add a few words to what the author had said. He commented that sometimes an architect's requirements impose difficult structural problems as when large areas have to be spanned without intermediate columns. In this case the architect's requirements could be met fully only by the method adopted. Precasting techniques were considered but providing continuity was extremely difficult unless a very complicated system of post-tensioning the slab was used and this would have put up the cost considerably. After considering a number of solutions, an insitu R. C. slab was adopted. It has to be completely shuttered because it cannot be cast in sections due to the nature of the magnitude and distribution of the B.M's and the possibility of the support conditions being upset.

The co-author in reply to Dr. D. A. Gunasekera, said that theoretically speaking a five point formula does give more accurate results than a three point formula. However, in a practical case as ours with a working material like concrete the values assumed for Young's Modulus, Poission's Ratio, Moment of inertia and the assumption that the material is homogeneous are only approximate so that the use of 5 point formulae involving more terms in the equation would not have been justifiable. The size of grid chosen which was 5' x 5' was in keeping with the overall size of the slab of 160' x 160'. Though a finer grid should theoretically give more accurate results, this is again subject to the same limitations mentioned earlier. With the 5' grid about 190 simultaneous equations were involved and could not be solved directly by a matrix inversion on the computer. The equations were solved by successive approximation and a reasonable convergence was obtained.

ERRATA

The following corrections should be made :-

1. Page 25.

NOTATION

$\nabla w = \frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2}$

q = Loading in finite Difference Analysis

$\nabla\nabla w = \nabla^4 w = \frac{\partial^4 w}{\partial x^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4}$

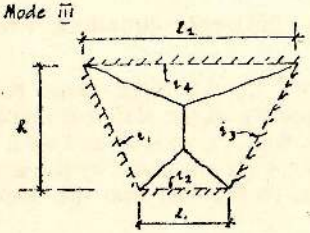
2. Pages 31 & 32

Appendix II

Mode I (assuming full fixity along supports ie, $i = 1$)

Mode II (" " " " " " ")

Mode III



Mode II $\bar{w}$ = Live load on edge around void.

APPENDIX V.

ANALYSIS OF PROBLEM

The differential equation $\nabla^4 w = \frac{q}{D}$ for the bending of a plate when applied to a point (I, J) on the slab, could be written as the difference equation:—

$$\{(w(I,J-2) + w(I-2,J) + w(I,J+2) + w(I+2,J)) + 2 (w(I+1, J-1) + w(I-1, J-1) + w(I-1,J+1) + w(I+1,J+19)) - 8(w(I,J-1) + w(I-1,J) + w(I,J+1) + w(I+1,J)) + 20\ w(I,J) \} \times \frac{1}{\lambda^4} = q \frac{(I, J)}{D}$$

By applying the above equation in turn to all the grid points on the slab, a set of simultaneous difference equations in w,—the deflection at the grid points, is obtained.

When applying the finite difference equation to a grid point on the free edge of the slab such as (12, 3), two extra points outside the boundary of the slab, in this case the points (12, 1) and (12, 2) will be involved. Corsesponding to each pair of such unknown deflections like w (12, 1) and w (12, 2) there will be two boundary conditions due to the fact that the bending and twisting moments and the vertical shear at a free edge is zero.

$$\frac{\partial^2 w}{\partial x^2} + V \frac{\partial^2 w}{\partial y^2} = 0$$

viz

$$\frac{\partial^2 w}{\partial x^2} + (2\text{-}v) \frac{\partial^3 w}{\partial x \partial y^2} = 0$$

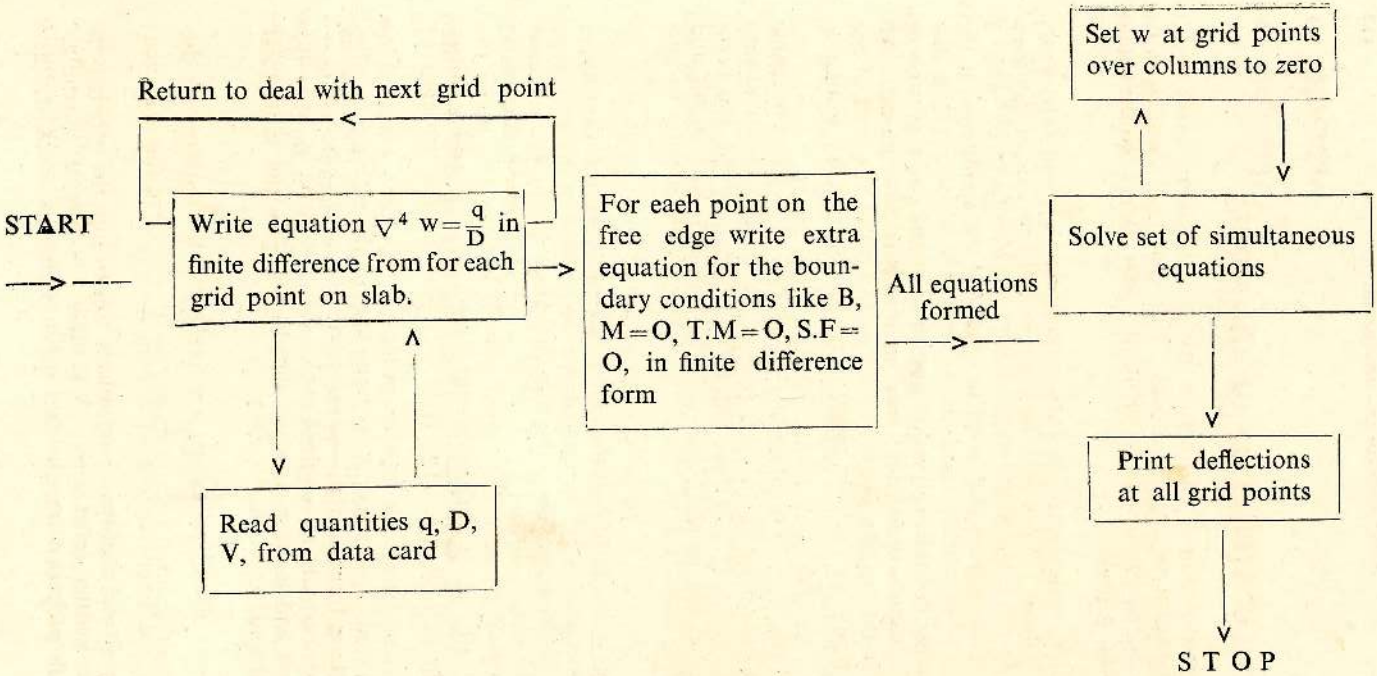
These could be expressed by two difference equations written for the point in question—(12, 3).

When considering the corner point (3, 3), three extra points (3, 1), (3, 2) and (2, 2) outside the boundary of the slab are involved thus introducing three further unknows w(3, 1), w(3, 2) and w(2, 2,). The three extra equations required in this case are given by the above two equations and a third equation due to the fact that the concentrated reaction at the corner is zero.

$$2D\ (1\text{-}v) \left(\frac{\partial^2 w}{\partial x\ \partial y} = 0 \right)$$

expressed by a difference equation written for the point (3, 3).

Hence the total number of equations will still be the same as the number of unknown deflections. A programme was written on the basis of the flow chart shown below for the solution of the equations.



FLOW DIAGRAM

APPENDIX VI

CONSTRUCTION OF THE MODEL

In an investigation of this nature one of the primary tasks is the design and construction of the model. For those not familiar with model analysis, we would like to mention a few basic considerations when designing a model.

(1) A suitable scale factor is chosen keeping in mind laboratory space available for test and the minimum dimensions of members e.g. Columns and Slabs that could be manufactured with a degree of assurance, the cover to steel and the soundness of the mortar. It should be remembered that a void of a $\frac{3}{4}''$ in diameter could considerably affect the performance of a $\frac{3}{4}''$ slab or 1" x 2" column dimentions used in this particular model. All credit for the success of the model should go to the staff of the Research lab for the care taken in its preparation for testing.

(2) Once the scale factor ($S = \frac{1}{16}$) is chosen it would be preferable to reduce all steel areas in the ratio S^2 but this is not always practicable as non-standard diameters result. Hence the practicable solution is to workout the area of steel/unit length and use available small diameter wires at a suitable spacing to give this area.

(3) The mix is designed to the same strength as the prototype. In this instance as $\frac{3}{4}''$ aggregate was to be used in the prototype in 3000 lb/sq. in. concrete the maximum size of the graded sand had to be scaled down to $\frac{1}{16} \times \frac{3}{4}''$ ie. o.o47". Hence graded sand passing through sieve No. 14 (o.o474") was used to make the mortar with an aggregate cement ration of 2:1, and a water cement ration of 0.5. This gave the desired cube strength of 3000 lb/sq. in.

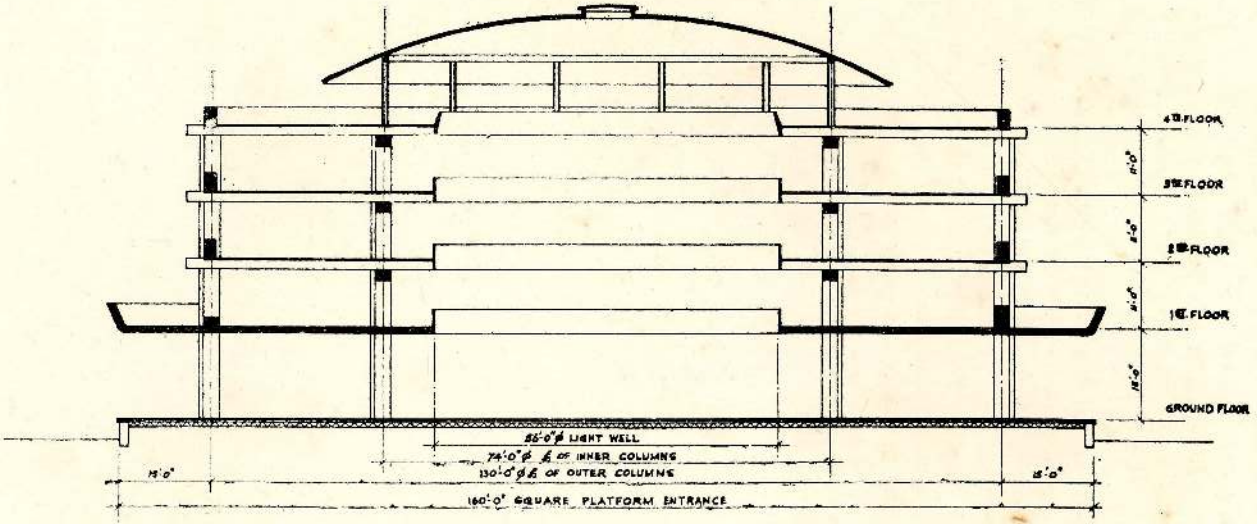
(4) The load/unit area (D.L. & L.L.) is required to be the same as that of the prototype. But as the D. L. is considerably reduced, 12" of concrete in the prototype as against $\frac{3}{4}''$ in the model, the L.L. has to be correspondingly increased to give the same total load/unit area.

(5) Deflections of the prototype are predicted by multiplying the deflections measured on the model by $\frac{1}{S}$ i.e. 16 in this instance.

(6) There is a considerable controversy regarding the prediction of crack widths in concrete structures. Numerous formulae have been proposed but the fact remains that as crack widths,

have the diamention of length, crack widths in the prototype should be approx $\frac{1}{s}$ ie. 16 times that measured on the model. This is not strictly true in this instance, as the spacing of the reinforcement bars in the model was not scaled down from the prototype.

It is generally agreed that a crack width in excess of $\frac{10}{1000}$" ie. $\frac{10}{1000}$" is detrimental to the steel reinforcement. Hence a crack of the order of $\frac{1}{1600}$" in the model could well mean a crack of $\frac{1}{100}$" in the prototype. It is regretted that cracks of this order could not be detected when they first occurred, while the crack detected in the model could have been of the order of $\frac{1}{1000}$" to $\frac{1.5}{1000}$' meaning fellure of the prototype at the load of 2.1.



SECTIONAL ELEVATION OF C.G.R. TERMINAL BUILDING

THE INSTITUTION OF ENGINEERS, CEYLON

Hydro-Meteorological and Climatological indications for the control and Utilisation of the Waters of Uda Walawe Reservoir and the Walawe Ganga

by Mr. M. M. ISMAIL, M. I. E. (Cey.)

DISCUSSION

Introduction

Mr. Ismail introduced his paper by stating that exhaustive details were given in it in order to make it useful to the student and expert, and in view of queries raised in Mr. D. L. O. Mendis' Paper the previous year. Details given were so methodically and constructively marshalled as to be easily checked up and verified.

Comments by Members:

Mr. P. M. Sithamparapillai stated that the learned speaker has made certain recommendations based on his studies, which were very elaborate. The recommendations are at pages 53 and 54. He thought that the case made out there was for the raising of the Uda Walawe Reservoir by 4 feet.

Turning to page 54, under para (h) he said that the author made a very salient observation regarding the maintenance of accurate rainfall and runoff records. He wished to make some observations on that aspect of the studies made.

In that particular case, the rainfall and runoff records that had been used had been made over a long period of time. During that period even the places from where those observations were made, were very remote. As recently as 12 years ago, Hambangamuwa was somewhat inaccessible. He said that many Irrigation Engineers present at the session would know that rainfall and runoff observations in remote areas during the 1930s, 1940s, and 1950s might not be quite good.

The fact of the matter was that elaborate calculations were being done for the Walawe area, where most of the recording stations were inaccessible, and were not checked properly. Mr. Ismail said that at Amparai, he personally made the observations. He said that most of the data that was used in the Walawe Basin should be taken with a pinch of salt.

He said that he visited one gauging station in the Walawe area in the early 1960s. Wanting to learn how the current-meter was being used. He went through the recordings, and found that there were some variations. Then the started stydying the booklet on the current-meter. The Gauge Reader explained to him how he used that meter, but to his surprise he had to explain to him that there was a switch to be turned if the stream velocity was high. If that switch had not been used, the error would have been magnified 5 times, or 1/5th, depending on the position of the switch. He appeared to have been unaware of that for may be several years.

Those were the records from which we were trying to build up the calculations. He thought that any recommendations which would be made in respect of Uda Walawe Reservoir—whether it was to be raised by 4 feet or not—might be delayed for some time. After all, there was no urgency. The Right Bank area had not been fully developed, and the Left Bank area yet remained to be done. Therefore, though a case was made out—no doubt—for further study, the case was not so urgent yet for raising the Uda Walawe Reservoir.

Mr. D. B. Anand said that he may be forgiven, for lack of knowledge of the country and, the details of the project, if his remarks were not quite applicable. Although, he had not enough time to fully study the paper, he said that there were certain clarifications he would like from the author.

In para 4, the author had mentioned that evapo-transpirational losses were observed from the evaporimeter. The loss from an evaporimeter corresponded to evaporation loss from a body of water, and, would not correspond to evapo-transpirational loss from irrigated land. Also the figures in columns 2 and 6 appeared to correspond to evaporation loss from a reservoir, and, would not, therefore. be applicable to loss from a catchment area. It was, further seen that although the losses were said to be based on figures established at Inginiyagala (cols. 2 & 6), the actuals adopted (cols. 4 & 8) differ therefrom, the total being 8.7" (about 13.5%) less than the former. The reasons for the variations were not clear.

The figures in columns 4 & 8 had been adopted to work out the run-off; it was not clear how that had been done. The real check was against the actual run-off. It might be clarified whether such a check was exercised on monthly, seasonal, and, annual basis, and, whether the actuals tallied with the calculated figures.

Since the runoff was an important factor in the design of the project, it was advisable to check up the basis before accepting a firm figure.

Mr. S. Sivasubramaniam referred to figure (3) of the above paper. He said that it would be seen that the run off obtained from the total rainfall of 90.47" was 45.69". He requested the author to explain as to how the weightages of the 7 stations were utilised to obtain the run off of 45.69" particularly because "Eggal Kalatota" one of the stations represented almost a third of the total catchment of 455 sq. miles and Hambegamuwa being located at a much lower elevation than stations like Diyatalawa, Ohiya etc. and also of lower rainfall than those stations. Incidentally that station too had been considered for Eggal Kaltota.

Mr. E. C. Fernando said he would like to refer to the last sub para of para 12 of the paper, appearing on page 46 of the Transactions for 1969 Volume I. In that sub para, Mr. Ismail points out that "almost every year there would be a shut down of Power in September and the storage would run down to sill of sluice, if the monthly quota of 2.0" were to be released for agriculture between June and September. This proves to case for 4 feet extra height of the spillway as indicated in para 12 above".

Mr. Fernando pointed out that the prospect of losing the entire input of power from the two Uda Walawe Power Stations to the Island Grid for a whole month is a disturbing prospect. If Mr. Ismail's forecast turns out to be correct, and all the indications are that an engineer with his experience is extremely unlikely to make a mistake, the Ceylon Electricity Board should take careful notice of this situation and provide accordingly in their power programme. 6 M.W. is an appreciable quantity of power particularly in the light of the fact that the system maximum demand is about 130 M.W. Energy-wise the possibility is that the 6 M.W. is available at a very high load factor.

Last month for instance, very considerable difficulty was experienced by the Ceylon Electricity Board in supplying the Island's power requirements, and that lends point to his remarks. Mr. Fernando asked whether anyone could let the audience know whether Mr. Ismail's welcome advice of a 4 ft. increase in the spillway height was going to be implemented.

Mr. D. L. O. Mendis thanked Mr. Ismail for the pains taken in preparing the paper. He thought that Mr. Ismail had spent about a month in Walawe for the purpose. The point he wished to make was in answer to what Mr. Sittamparapillai said about the urgency of changing the design at Walawe. As he had pointed out last year, the designs were prepared by Consultants. His interpretation of the figures were that it was not maximum probable floods. He felt that a communication system could be set up in the Upper Walawe so that the floods could be controlled.

Mr. M. D. W. Perera said that Mr. Ismail had submitted several papers on the subject of Hydro-meteorology and climatology. Each time, his knowledge and experience seemed to have widened, and the paper presented showed his immense capacity for the pursuit of details If Mr. Ismail's wide knowledge and experience could be utilized elsewhere, like for instance the controlling of floods in the Kalani Ganga it should be possible to avoid most of the damage caused by these floods in, and around Colombo. The present annual cost for the maintenance of flood controlling devices in and around Colombo was about Rs. 2.5 million.

He added that last year the Electrical Department tried an experiment on the Castlereagh Reservoir on the upper reaches of the river, by delaying the rush along Kehelgamu Oya. They were satisfied that, the intensity and volume of floods in Colombo was considerably reduced by that. Flood water rushing down from the upper reaches of the river caused most of the damage from Avissawella to Colombo because, the throttling of free flow due to the Victoria Bridge (60,000 cusecs) bottleneck, caused back-flow, on colliding with the former, overflowed to inundate.

Commenting further he said the paper also stated in page 53 para 21 that "Total flood absorption in the proposed Samanala Dam will automatically reduce the intensity of floods in Uda Walawe by 46%. The 600 mile Tennessey River in the H.S.A., and the Demodhar River in India, were two other examples where flood control was effected with the help of Reservoirs.

Mr. Perera said that floods in Kelaniganga could be similarly controlled by means of the two existing reservoirs Castlereagh, and Mousakelle, on the Kehelgamu Oya and Maskeliya respectively. That however, required trained staff for flood forecasting through meteorological observation, and computation.

The authorities concerned should take full advantage of the experience and talents of Engineers like Mr. Ismail, who have specialised in the subject to help organise such effective means of controlling storm water flow at the above reservoirs. Confining his activities to Walawe and Gal Oya alone, was depriving the country of the benefit of his services, which could be used to greater advantage, elsewhere.

Author's Reply

In reply to Mr. P. M. Sittamparapillai, Mr. Ismail remarked that it was uncharitable and unscientific to cast doubt on the accuracy of rainfall records in view of the fact that the figures had the check of the Department of Meteorology and still further by the Canadian Survey team. As mentioned in para 2 of the paper, Mr. Sittampara-

pillai and others who shared his views were recommended to study the book published by the Canadian Survey team. Rainfall figures taken by Mr. Ismail off this book are thoroughly reliable. Run-off is given the effect of post-scheme augmentation by the presence of large sheet of water in the reservoir which would register 100% of the rainfall as immediate run-off. If the construction of Samanalawewa Dam is taken up within the next ten years there will be no necessity to raise the spillway gates by four feet. Even so the fact remains that it was unfortunate shortfall in the design. This could have been avoided if a thorough study of hydrometeorology and hypothetical operation of the intended reservoir were made as per para 12 of Mr. Ismail's paper.

Replying to Mr. D. Anand, the author stated that it was unfortunate that the former was yet new to the Island and the new ground gained in the matter of Irrigation Engineering in Gal Oya Valley where the author had made extensive study of rainfall, run-off, climatological studies, meteorological observations as embodied in his papers submitted to this Institution and the South-East Asia Regional Technical Conference of December 1960, and designed the construction of non-spilling Dams on Pallang Oya and Ambalan Oya etc. with the provision of storage capacity of 200% of the long term average run-off which Mr. Ismail established beyond reasonable doubt. These were based on figures and graphs comparable with those given in the Paper under discussion.

Mr. Ismail reminded Mr. Anand that apart from the design and construction, he had the satisfaction of being in charge of the maintenance and working of these schemes for more than 10 years! and that Mr. W. T. I. Alagaratnam (past member of the Gal Oya Development Board) was fully aware of and was satisfied with the theory established by Mr. Ismail.

Evaporation observations were conducted by Mr. Ismail for over ten years at Inginiyagala in evaporation established and handed over by the Irrigation Department. The author reminded Mr. Anand that apart from evaporation from a body of water as per columns 4 & 8 of page 37, allowances had been made for evaporation from ground and transpiration of vegetation and percolation into ground in arriving at the smooth curves of daily and monthly run-off (page 38) and figures taken off them as in page 39. Mr. Anand was recommended to study the details.

In reply to Mr. S. Sivasubramaniam, the author recommended him to study and check up the obvious details given in graphs of page 38 and the figures on page 39. Other points raised by him are treated in the replies to Mr. D. Anand and Mr. Sittamparapillai.

Replying to Mr. E. C. Fernando's comments, Mr. Ismail agreed that there was loss of water and consequent to loss of power generation in the four month dry season purely occasioned by the short-fall in storage capacity. This in turn was brought about by imperfect analysis of flood potentiality with reference to the rain-shadow caused by the horse-shoe pattern of 4500 feet high mountain ranges which strut out upper catchment area of Uda Walawe effectively against the extreme depressional and cylconic intensity of rain storms. Mr. Ismail reminded that such loss of vital run-off could be off set by nearly 15% tail drainage off the irrigable command area of the proposed Samanala Dam.

Engineers in charge of the Dam will do well to assess the loss of water and Power in the dry season and present a Paper to this Institution in due course.

The author replying to Mr. D. L. O. Mendis' remarks made the correction that he spent only one night and part of a day at Uda Walawe for which he was thankful to the Chairman and Engineers of the R.V.D.B. Mr. Ismail was emphatic that the 1250 feet wide spillway was unnecessary except as a breaching section at **296'** M.S.L. It should be bunded to that height, viz. 6' above the present spillway gate at 290' M.S.L. without any hesitation. The spill tail channel need have accommodation only for 110,000 cusec as per hydrograph on page 48. Its preparation in the form of a line diagram is simple and instructive in the diagnosis of an on-coming flood intensity, as indicated in para 23. Mr. Ismail expressed his thanks to Mr. Mendis whose queries and doubts had brought out instructive details.

In reply to Mr. M. D. W. Perera, the author thanked him for his kind words and reminded him that he (Mr. Ismail) had made extensive study of the flood problems in Nilwalaganga and Kelani Ganga and made reasonable reports to the Director of Irrigation to the effect that full flood absorbing reservoirs are possible in these two valleys but they were uneconomical in that their construction would involve the submersion of extensive developed areas of towns, roads and railways which the country could ill afford. On the other hand. Mr. Ismail mentioned that he was now working somewhere on the right bank of Mahaweli ganga and that he hoped to make some contribution to the design and planning of projects in that area.

THE INSTITUTION OF ENGINEERS, CEYLON

A Pressurised Solar Water Heater of the Combined Collector and Storage Type

by Prof. J. C. V. Chinnappa, B.E., D.I.C., M.Sc. (Eng.) Lond., Ph.D. (Lond.), C. Eng., M.I.Mech. E., F.I.E. (Cey.)

DISCUSSION

This paper was not presented at the Session as Prof. Chinnappa had to keep away due to unavoidable circumstances and the Chairman invited written observations of members on the Paper.

Comments by Members

Mr. E. C. Fernando said that the paper had the outstanding merit of sound practical value. He expected many people to instal these heaters and benefit from their utility.

It is of interest to note that based on the figures of total insolation in column 9 of Table I, the corresponding KW hours vary as follows:

Total Insolation B.T.U.

Date	Total Insolation	K.W.H.	Value at 15 cts. per K.W.H.
			Rs. Cts.
Jan. 22	28,450	8.3	1.24
,, 24	39,600	11.6	1.74
,, 25	39,950	11.7	1.75
Feb. 11	41,450	12.3	1.84
,, 12	43,400	12.7	1.90
,, 13	40,000	11.7	1.75
,, 14	37,500	11.0	1.65
,, 15	29,700	8.7	1.31
,, 19	39,600	11.6	1.74

For the particular days in question in January and February therefore, the utilitarian value of the Solar Water Heater per day would vary from about Rs. 1.25 to Rs. 1.90. Whether these figures present the best possible picture of the arrangement is not clear, but even assuming that they do present the best value from the equipment

it would seem that the capital cost of the arrangement taken at about Rs. 400/- would be more than recovered in about a year, with electrical energy at 15 cents a unit which is the prevailing cost.

Author's Reply

Mr. E. C. Fernando's comments are most pertinent. They do, in fact, relate to the best possible conditions and so must be considered as optimistic.

The electric hot water heater using immersion coil will have a better efficiency as heat exchanger. The main reason however why Mr. Fernando's figures are optimistic is the occurance or partially or completely overcast days. In fact in order to provide a consistent daily supply of hot water, it would be necessary to have **both** an electric heater and a solar heater. The electric heater would operate only when the solar heat was inadequate. The saving in the cost of KWH would then be offset against the increased cost of the installation. Even in these circumstances it has been shown that a saving is possible in locations with annual insolation data similar to that obtained at Colombo. (Czarnecki JT: "Economics of Solar Water Heating", Solar Energy Progress in Australia and New Zealand, No. 7, July 1968, p. 19)

THE INSTITUTION OF ENGINEERS, CEYLON

Some considerations in running High Speed Trains on the Ceylon Government Railway

by Mr. L. SYDNEY DE SILVA, B.Sc. (Eng.) Hons. (Lond.), C. Eng., F.I.C.E., F.P.W.I. (Eng.), F.I.E. (Cey.), M. Inst. T. (Lond.)

DISCUSSION

Introduction

Mr. R. Ratnasingham in introducing the Paper said he believed that everyone would have read the full text of the Paper. He added that he did not propose to read the article, except to read out a summary prepared by the author himself as he had fallen ill the day before.

In the Paper the author had dealt with some of the most important factors that should be taken into consideration before running high speed trains (i. e.) running trains with a speed of over 75 m.p.h. Ceylon had to go a long way before high speed trains were allowed on the tracks—such as by eliminating level-crossings or providing automatic barriers. The cost of achieving that would be very high. The speed of the Ceylon railway would have to be increased in stages, carrying out the improvements gradually to achieve something substantial in the future at least.

Mr. Ratnasingham added that the author had requested that any doubts or questions regarding the Paper be sent to him in writing and that a written reply would be forwarded in due course. However, if there was any matter that he could help in, he had no objection in answering such question.

Comments by members

Mr. C. Kalidasan said that it was a pity that Mr. de Silva had fallen ill and was not in person to present the paper. He was sure that the paper would create very wide interest. Personally he would have desired if Mr. de Silva had incorporated more local information. He said that he had to make a few observations. At p. 91 the maximum speed on the Indian Railways was yet only 60 m.p.h. except on the Calcutta-Delhi route. Compared with that speed, the Ceylon Railways were not far behind. Increase in speed required capital expenditure. He considered some of the curves on the Northern Line could be eased and by providing crossing loops it would be possible to save about an hour on this run. On p. 93 (1), he did not fully agree with the one point contact profile as mentioned. The Railway

has now tried out a new German engine. He said that there should be some sort of thinking on the one point contact. On p. 97 there appeared to be some confusion in the tables given. 4.5 is allowable for wagons in the second table. On p.99 under Recommended Track Tolerances, he said that the author should specify the high speed possible. No mention had been made for track tolerances. P. 100 gave the design of turnouts of high speed trains and the point over which it was to be located on the curves etc. More complicated scissor arrangement was required, particularly when over 1500 kilos p.h. are attempted than the network of conventional type of crossings. Referring to p. 104, he said that he would have liked if the author could say what the practice of L.W.R. or the Indian Railways was, what methods they adopted to unload the rails on the site etc. The Mono block slab will be subject to the same disadvantage on soggy formation. Re p. 105 there was additional information available in the June 1967 JRE. Within the next two decades the Railway would reach the bottleneck of full track capacity. JNR have located additional tracks for their main lines on a seven year plan. The Railway should ease the sharp curves in order to gain running time.

Mr. J. P. Senaratne said that due to lack of funds the programme of realigning curves had to be held up. The Treasury gave only a small amount to the Railway. The maintenance of the track was done with the amount of money given. The Department had started on the use of coach screws where there was a positive connection between the rail and the sleeper instead of just a nail. It had also started using long welded rails by using the thermit process. For one joint it cost about cts -/35. The test lengths of these thermit welded rails generally have been running well. The experience gained from France was that they had saved about 50% on maintenance by this means.

About the heavier rail that had been suggested by Mr. de Silva, the Railway has looked into this, but here again it was the cost that was involved. Now the Railway wagons and locomotives have been designed on a certain axle load. If the rails are changed, then of course a heavy axle load can be carried, but this cannot be done piecemeal.

He further said that on the Ceylon Railways and the Indian Railway, there is no cant in turn-outs and that is why there is a caution on the curve. If trains are to negotiate the curves at the same speed, cant must be provided. On the French Railway, they have developed a type of cant crossing, so that trains can take even the turn-out at speed. If the Railway must increase its speed, the track must be canted at the turn-out itself.

If one considers the Yokobori bogies, then travelling in the air-conditioned carriage that runs up to K.K.S. and back, Mr. Senaratne said, no one would feel he is going on the same track. Hence he said the suspension of the carriages, should be improved as in modern cars. That is, the suspension should be improved irrespective of the condition of the road, as it would cost a great deal to bring the road to that standard. It might be cheaper in the long run to improve the suspension of the carriages. The two bogies that were mentioned earlier, cost something like Rs. 60,000/-. They were presented by the Japanese Government to Ceylon. Most of these improvements were tied up with the economic conditions of Ceylon and he hoped that in the near future, the Railway Department comes out of the woods and gives the travelling public a better railway to run in.

Mr. T. W. U. Seneviratne said that with regard to the question why there were smaller wheels in electric trains and larger wheels in steam trains, in thecase of electric trains the running motor had to be worked faster. So, in electric trains the wheels were smaller than in steam trains. The steam train was more effective in disturbing the track due to hammer blow.

In regard to how far the Railway needs to increase the speed of trains, the maximum journey is some 256 miles and the maximum speed today is 50 m.p.h. The maximum journey takes 8¼ hours; so the average speed is still much less than 40 m.p.h. He said that he would like to know how far or how much more the Railway should increase its speeds. What is required is to reach the destination as quickly as possible. For this purpose, he thought the Railway required more crossings, and also a better timing system by which the trains can be spaced out. These are some of the problems which the Railway will have to tackle with the increase in speed. The question of money, of course, is always there. What has to be found out is how the railway should achieve these ends with the least expense.

Mr. D. T. Jayamanne said that it was not advisable to raise the speed of trains as it would not be an economical proposition because the Government was losing about 20 millions a year in running the Railway. Although that was a big financial loss it provided employment to thousands and thereby rendered a service to the country. He asked whether it was worth spending a large sum of money for saving one hour in the travelling time of a passenger to Jaffna, without a compensatory increase in income. If an official or a business-man wanted to go to Jaffna quietly he could travel by air.

He further said that today the country was on the verge of bankruptcy. Ceylon was so much indebted to foreign countries that in a few years' time she would not be able to pay the interest on her debts,

leave alone the capital she had borrowed, and financially and economically she might become a 'property' belonging to foreign countries.

He also said that the purchase value of a rupee today was only 20 to 25 cts as compared to the days when Ceylon enjoyed greater financial stability. Any money spent should be as an investment rather than saving one hour to the travelling public, particularly when other things move very leisurely. It would be a better proposition to electrify the Railway for short distances say from Colombo to Polgahawela-Kalutara-Negombo, if the Government can find the money. This would bring about a saving in foreign exchange by the utilization of electricity as motive power instead of imported fuel.

Mr. E. C. Fernando referred to the observations on Page 104 where it is remarked that though Diesel and Electric Locomotives are free from Hammer Blow and Steam Effect, they have smaller diameter wheels which result in very high comprehensive stresses on the track requiring increased track maintenance. The anuthor had pointed out that this is also due to part of the dead weight of the motor being carried on the motor suspension bearings on the axle.

Mr. Fernando remarked that the weight of the steam cylinders and pistons together with the piston rods cross heads and so on, would appear to be larger than the weight of the motors in the case of electric drive, and he enquired how it came about that the stresses on the track in the case of electric drive were more severe than with steam drive as was suggested by the paper. If larger diameter wheels would tend to reduce these stresses, presumably, it was a matter of economics to decide whether larger diameter wheels should be used in electric drive with a view to decreasing track maintenance cost.

Mr. E. C. Fernando also raised another question in regard to Page 97 of the Paper where reference is made to the Ride Indices. He drew attention to the table in Page 97 where the Ride Indices in decreasing order of riding comfort, vary from 1.0 to 5.0 with the corresponding Riding Comfort or Appreciation as termed in the paper, vary from Very Good to Almost Very Good, Almost Good, Satisfactory Almost Satisfactory, Tolerable, Not Able To Run and Dangerous, the last that is, Dangerous corresponding to Ride Index 5.0. Mr. Fernando pointed out that whilst the terms of Appreciation from Very Good to Tolerable and even Dangerous, could be readily understood, the Appreciation of Not Able To Run against Ride Index 4.5. was not understood.

Reply by Mr. Ratnasingham

Mr. Ratnasingham replied that he did not venture to answer all the questions raised by Mr. Kalidasan, but in fairness to the author

it would be seen that the author's article was only on some thoughts on the future speeds that could be developed in the Railway system. It will be seen that on p. 92 it has been contemplated or suggested only to take such steps without incurring heavy expenditure so as to increase the speed to 60 m.p.h. which is an increase in speed, for the present by 10 m.p.h. The Railway still has restrictions due to sharpness in curvature, but still it may be possible to increase the speed to 60 m.p.h.

The second point, he said, was on the profile of 1 point contact. This is really called the Heumann Profile. The experience referred to by Mr. Kalidasan, he presumed, was in regard to locomotives with this Heumann profile being run on the rail which is not in similar profile. The tyre profile, if it is not developed on the rail profile, the conclusion arrived at should not be a deterrent to consider or to reasonably examine the new proposal of single point contact which will definitely produce better running conditions.

Mr. Ratnasingham said in regard to the cost on the question of increasing the speed of trains that it was not correct to weigh this question in the light of one financial year budget. It was the author's intention to spread out the cost over a period of 20 to 30 years, and when it is looked in that manner it would be very much cheaper to replace the wooden sleepers by concrete sleepers. It should be spread out over a relative long term. The idea of the Paper is to suggest improvements that would possibly be implemented with the available financial resources. In the long run with these modifications the annual maintenance cost will show a comparative saving. The increase in speed from 50 to 60 m.p.h. was suggested with the intention of keeping the cost to the minimum, as it was not proposed to expend such a lot of money to remove the curves.

He drew the attention of the members to a small drawing error in Fig. III which should be rectified. That is, the switch blade was shown outside the main rail which should not be the case.

With these few comments, Mr. Ratnasingham thanked the members for having patiently listened to his version of the article, of which he was not the co-author.

Written Reply by Author

Mr. L. Sydney de Silva congratulates Mr. R. Ratnasingham for his fine performance in presenting the Paper in his absence, and for the replies he had given to some of the questions raised at the discussion.

Mr. de Silva mentioned that Mr. Kalidasan should be reminded that no work except realigning some curves had been done on the

subject in Ceylon for incorporation of any more local information. It would not be possible to cut down on the travelling time from Colombo to Kankesanturai by one hour for express trains by providing crossing loops, as express trains are even now not held up long at stations for crossing slow trains. Instead the slow train was made to wait, till the express comes and crosses it, even though it may be the express that is running late. The one-point rail to wheel contact definitely gives better running in that hunting is eliminated, but the rail profile should be designed to match the wheel profile for better adhesion. There need not have been any confusion about the Ride Index of 4.5 allowed for wagons, if the Fatigue Time and appreciation had been read in relation to Passenger Comfort and Stability. Speeds had definitely been specified in respect of cant tolerances, but in respect of alignment, twist and unevenness it was clear that the tolerances laid down were the same for all speeds from 120 K.m.p.h. to 210 K.m.p.h. when the reference was to high speed trains. Since changes in gauge are detrimental to travelling comfort at high speeds of 120 K.m.p.h. and above, gauge tolerance are theoretically not allowed. Hence no mention had been made in the Paper. However, a maximum variation from sleeper to sleeper of 1 m.m. may be tolerated in actual practice. The basis of design for more complicated track layouts is still the same as the simple turnout, and cannot be gone into fully without making the Paper unnecessarily voluminous, in as much as the method of unloading rails at site is a matter which is not considered germane to the subject at issue. In view of its continuity of bearing, the cross-levels will not be affected on soggy formation to the same extent with a mono-block sleeper as with the twin block type connected by a tie bar.

Regarding the question of lack of funds raised by Mr. J. P. Senaratne, Mr. de Silva states that he made that point quite clear in the 'Conclusion' to his Paper, and a humble start in the correct direction though in a small way was what was required. It would be encouraging to realise that high speed trains between Delhi and Calcutta had been made possible at minimum cost on existing permanent way material with improved standards of maintenance, without effecting alterations at prohibitive costs. The change should be gradual and spread over the years, but what was important was to make a start somewhere.

In replying to Mr. Jayamanne's remark, he states that the concept of saving an hour for a single passenger who could very well travel by plane was not the intention behind the Paper which considered the benefits to the general public at large. How many of them could afford to travel by plane? The traffic density on the Ceylon Railways does not justify electrification, and the present system of dieselisation with colour light signalling for the suburban traffic was considered more than adequate for the present.

Regarding the questions raised by Mr. E. C. Fernando, the smaller diameter wheels of the Diesel and Electric Locos at high speed are definitely more harsh on the track than the periodic hammer blow effect due to out of balance of reciprocating parts produced by larger diameter wheels of slower steam engines. Smaller diameter wheels are used in Diesel Locos to develop higher angular velocities in motors for the same linear speed, but the same high angular velocities cannot be allowed in working the reciprocating connecting rods and pistons of steam engines. Hence the wheels of steam engines have to be larger. Further, with the introduction of diesel or electric traction to haul heavier loads at high speeds, the wheel diameter had to be reduced to bring down the level of bogie underframes to provide more serviceable space inside rolling stock. There was no sudden change of concept from a Ride Index of 4 to 4.5. The Ride Index of 4 corresponds to a fatigue time of 1½ hours and could be just tolerated by the passengers, whereas a Ride Index of 4.5 could not be tolerated by the passengers due to severe jolting, and they were fatigued out too in half the time:

Before concluding, he mentions that he must refer to a few typographical errors which had crept into the Paper, and which he regretted. They are:

Page 96, Last para, first line, the word 'difficult' should be replaced by the word 'sufficient'.

Page 102, second para, second line, 40% should be replaced by '45°'.

Page 103, line 12, 'α' should be replaced by 'and'.

Page 105, penultimate para, 3rd line, 'girder' should be replaced by 'bridge'.

Fig. 2, $\beta = 68°$ (not 65°), corresponding to the safety height position.

Fig. 3, the stock rail on the closed-in switch side should be outside the switch rail.

THE INSTITUTION OF ENGINEERS, CEYLON

Reclamation and Development of low lying coastal lands in Ceylon

by Mr. A. T. G. A. Wickremasuriya, B.Sc. (Lond.), B.E., A.M.I.E. (India), F.I.E. (Cey.)

DISCUSSION

Introduction

The author presented this Paper in an unusual manner, i.e. by tape recording his introduction and by show of slides. As it appeared to be lengthy and completely impracticable at the Sessions, the President decided with the author's permission to terminate his interesting lecture due to want of time.

The President then announced that the Paper was open for discussion.

Comments by Members

Mr. Ismail stated that long association with the reclamation work taken up in Muthurajawela in 1948 or thereabout confirmed the view that dredging and canalising the marshy areas of Muthurajawela was not conducive to all-time success of paddy cultivation, since the floods of Kelani Ganga any time in the only crop-season April-August were a frequent source of disaster. A crop of Devaraddiri paddy succeeds only during 25% of time when the S. W. Monsoon and consequent floods of Kelani Ganga are at the lowest quartile. This phenomenon has given rise to the popular and perhaps politically sentimental talks that Muthurajawela gave good crops 'in the time of sinhalese kings.'

Mr. Ismail referred to the reclamation work done by the construction of sea out-fall groynes at Wellawatte and Kaikawela and recommended Mr. Wickramasuriya to study and publish the details of the measure of benefit gained by such work in order to launch on larger projects of that nature.

Mr. Ismail made reference to the commendable housing project at Maligawatte on the low land within the total floods protected area in the municipal limits of the city of Colombo, which is quite a contrast in utility and financial aspects.

Mr. H. de S. Manamperi said that Mr. Wickramasuriya tried an original approach to present his Paper. In the Paper he had covered a vast area of ground. He suggested that the author should have confined himself to one particular aspect of the vast problem and dealt with it in greater depth; then he believed the information would have been more valuable.

For the last three years, he said, the Irrigation Department had been trying to expand the Research Station. The Department had obtained forty five acres of land about seven miles from Colombo, but, unfortunately, there were squatters on that land. The assistance of the University was sought in the research activities.

Mr. Wickramasuriya had referred to the use of water in the Mahaveli Diversion Project. The Department had examined the waters and the Mahaveli waters fell into Class A1—the best water that could be got except the waters in the Parakrama Samudra which fell into A2, but it was good for cultivation.

In conclusion, he added that he would like to mention that the works that had been created for drainage had very often been used for purposes in connection with fisheries. He said that there was no sufficient co-ordination of efforts in that regard. There was quite a conflict when the Department opened the Iranwila Drainage Project. He felt that those two factors had to be taken into account and also to see what changes took place when the water levels were reduced in the low lying areas and what effect it had on fish life. That was an aspect, he thought, fully worth considering. It was not only to the improvement of drainage was to be seen, but also to give due consideration to fish life.

Mr. K. R. de Silva commenting on the above paper stated that regarding marshes like Muthurajawela, salt intrusion might be caused by the Sea waves which wash the shores up to a height of nearly 8-10 ft. above M.S.L. Such constant doses of sea water might gradually percolate through the marginal belt of high land into the low marshes.

He further said that it might be possible to prevent the salt water intrusion by isolating a small area of the marshes and placing a clay grout curtain just above the shore line and parallel to it. The area thus protected could then be leached out, if necessary by pumping.

Mr. L. R. L. Perera stated that he wished he had the above paper to hand much earlier. He said he had just glanced through the paper. He wondered why the Irrigation Department did not resort to pumping in land reclamation. The Department of Agriculture had not done any large scale investigation in the matter of land reclamation. The Agricultural Department understood that it was a matter for the Irrigation Department.

However, they had resorted to a little pump drainage for the purpose of water-weed control, specially Salvinia, on which Government was spending a lot of money annually. In about 1961 the Department thought of draining out the area around Attidiya in an effort to control Salvinia in that area. The Department of Agriculture installed the pumps to pump over the Irrigation Department Lock Gate in Attidiya and as a result about 600 acres of land became cultivable. Most of the marshes are due to the fact that most of the waterways intensively used in the past are blocked and silted. The Department had a small dredger for the purpose of clearing those narrow water-ways. However, it had not been possible to make a good programme because it was not a matter for the Agricultural Department.

Mr. Perera said that the cost of land reclaimed by pumping was very much cheaper than land developed in the dry-zone by gravity irrigation done by the Irrigation Department. Moreover the intensive cultivation that could be done in the wet-zone might become much more gainful to the country. Recently in Akurala, at the 56th mile-post on Galle Road near Ambalangoda, the Agricultural Department installed some pumps to pump water over the sand bank and almost immediately about 85 acres in the upper reaches were made cultivable.

It was estimated that in Maha 69/70 a total of 325 acres could be made cultivable. The cost of complete installation including cost of pumps were less than Rs. 50,000/-. That compared very well with the development done by the Department of Irrigation in the Dry Zone which was more than Rs. 3,000/- per acre. That scheme also had been haded over to the Irrigation Department and the G.A. Galle. He hoped that the Irrigation Department would maintain and keep careful records. Salinity tests were being done by the Department of Agriculture.

Mr. Arunakirinathan while congratulating Mr. Wickramasuriya, said that some time back Mr. Wickramasuriya had presented a similar paper on reclaiming low lying areas around Beira Lake, and from that they were aware of the interest Mr. Wickramasuriya has taken of the Low Lying Areas. He hoped that in time to come Mr. Wickramasuriya will select an area to be reclaimed and present a paper out-lying in detail the proposals to reclaim same.

Mr. Arunakirinathan pointed out that to be a Drainage Engineer one must have a back ground of Hydrology, Hydraulics and if the lands reclaimed are for Agricultural purposes, then a knowledge of Soil Chemistry and Soil Physics too was essential. He hoped that experts on these fields will give a helping hand to Mr. Wickramasuriya when he presents his next paper.

Mr. Arunakirinathan stated that the paper did not mention about maintenance of the Drainage Scheme. He pointed out the difficulties the Irrigation Department had in maintaining the schemes due to lack of funds, divided responsibility and that unless a Drainage Engineer puts forward concrete proposals for effective maintenance, an improperly designed and maintained reclaimed land is likely to bring disaster.

Mr. D. T. Jayamanne said that the paper was of particular interest to him as it referred among other things to the development and reclamation of Muthurajawela for the simple reason that he had vested interest in the land that would be effected by such reclamation.

Commenting further he said the paper also stated in para 2 page 1, that "In the planning and designing of flood protection and drainage works, attention should be paid to the possible adverse effects that might develop in the course of time by the disturbances in the existing conditions of soil and water as a result of the work done". This was a very pertinent warning by the author. That was also correct where a regime of a river bed was disturbed. He referred as a case in point to the dredging of the Kelani River at Peliyagoda to reclaim marshes and build a road. As a result of removing the material from the river bed, erosion took place on both banks of the river and if dredging was continued the river would soon eat up a section of the Negombo Road. It had already reached a danger point as the reservation between the road and the river had narrowed down to 10 to 15 feet or even less.

On the left bank bordering Mattakkuliya several coconut trees have been uprooted as a direct result of dredging not to mention the damage to the coast-line at Palliyawatte.

Further he said that as that was an important technical problem arising from the haphazard dredging of the river bed, he wished to bring to the notice of the Institution so that the authorities concerned might investigate the problem in order to arrest further damage and restore stability of the river banks.

He also said that it should be a matter of concern to the Highway authority as it endangers a trunk road.

Finally he said that his observations were based on the following technical aspects of the case.

A river established its own regime in course of time according to the detratus matter it brought down with the floods. The regime varied according to the fluctuations of the floods. Now to upset the regime was to upset the established course of the river. One way to upset the regime was to dredge the river bed. If the amount dredged

exceeded the normal build-up of the bed during the flood receding period the shortfall of bed-building material must be supplied by other sources. One such source was the erosion of the banks to supply the shortfall. Where banks are high that was inevitable. Where the banks are shallow a change in the river course was inevitable. It would aggravate matters if there were to be changes in the flood cycle.

That kind of bank erosion had taken place in the past around Kaduwela, and Hanwella where there had been intensive removal of sand. Several buildings including a church had been eaten away into the river. Likewise, he said the present operations at Peliyagoda will certainly eat into the Negombo Road.

He concluded by saying that man must learn to work with Nature and not against Nature. He must learn to benefit by harnessing the dormant and hidden potentials of Nature. There was a limit to which Nature would tolerate man's interference in her domain and if man exceeded that limit she will revolt and retaliate.

Mr. A. N. S. Kulasinghe stated that since it came under his area of work, he considered it was his duty to say a few words on the matter. He said that the whole situation had been exagerated considerably. There had been no serious erosion along the Negombo Road. The particular spot mentioned by Mr. Jayamanne had been close to the road all these years. He added that there were a few coconut trees that had been uprooted for other reasons.

That was something which was anticipated, he said, and coast protection work was going to tackle the problem of erosion. Erosion is not solely due to the dredging of the river, because it had been happening long before the dredging started. He further said that he could assure Mr. Jayamanne that erosion problems were being watched.

Author's Reply

As the author did not wish to reply, the President thanked the author for presenting the paper which stimulated much discussion.

THE INSTITUTION OF ENGINEERS, CEYLON

MINUTES OF THE ANNUAL GENERAL MEETING, 1969

Minutes of the Sixty Third Annual General Meeting of the Institution of Engineers, Ceylon held at the Irrigation Department Auditorium at 2-30 p.m. on 23rd October, 1969.

Mr. A. N. S. Kulasinghe B.Sc. (Eng.) Hons. (Lond.), C. Eng., F.I.C.E., M.I.E. (India) F.I. Mech. E., F.I.E. (Cey.), President occupied the chair.

The President stated that the Minutes of the previous Annual General Meeting had been printed and sent to all members. He sought the permission of the House to consider it as read and the House agreed. He then called for any comments.

In the absence of any comments, the adoption of the minutes was proposed by Mr. M. Mathurunayagam and seconded by Mr. P. H. Perera. This was passed by the House.

The President stated that he had to announce with regret the deaths of the following members during the year under review:

Mr. N. Periathamby	—	Fellow
Mr. S. Subramaniam	—	Fellow
Mr. T. Sinnadurai	—	Student

At the President's request the members observed two minutes silence as a mark of respect in the usual manner.

The President then announced that the scrutineers of the Voting Papers for election of Members (Fellows class) had reported as follows:

Prof. J. C. V. Chinnappa	—	93 votes
Mr. L. S. de Silva	—	84 ,,
Mr. S. W. Peiris	—	80 ,,
Mr. P. H. Perera	—	80 ,,
Mr. L. Sydney de Silva	—	72 ,,
Mr. G. D. Somasundaram	—	65 ,,
Mr. H. de S. Manamperi	—	65 ,,
Dr. K. Mahadeva	—	43 ,,

Only six Fellows are to be elected to the Council. In this case there was a tie for the 6th place. His task had been made easy by the Council which had recommended Mr. G. D. Somasundaram as one of the members of the Council. He would therefore give his casting vote to Mr. G. D. Somasundaram.

Report of Council for 1968/69:

The Hony. Secretary then presented the Annual Report and made the following remarks:

Membership—The membership has steadily increased and this was probably due to the recognition of the Institution by Government. The large increase reflected in the Student membership was presumably due to the Institution conducting its own Professional Examinations.

Headquarters—The Council decided to construct for the present only two bays of the Auditorium block due to limitation of funds as the Government had not made any provision in the Estimates even in 1969-70.

Examinations—The Institution held its own professional Part I Examination in August. Although 104 candidates applied to sit and were eligible the actual number which sat was 95.

Steps were being taken to conduct the Part II Examination in Civil, Mechanical and Electrical for the first time in 1970.

Recognition of membership—The Government had now recognised the Diplomas granted by the Institution and a circular letter had been sent accordingly by the Secretary to the Treasury to all Permanent Secretaries and Heads of Government Departments. This matter had been pursued for almost five years by the Institution.

Bulletin—This is now being published regularly, however, the Editor would appreciate more articles from the Members.

Library—Donations of technical books have been received from members. A fairly large quantity of books had been ordered and they are expected shortly from abroad.

The President then stated that the Report was open for discussion.

Mr. A. Maheswaran said that the report indicated that a start would be made in the construction of the Headquarters building. He inquired what the total cost would be and whether it would be constructed in stages.

Mr. H. de S. Manamperi speaking on the Joint Part I Examination, stated that the results were very poor and that it needed some serious consideration of the Council. In regard to the recognition of degrees of the Lumumba University, he said that those who obtained those degrees were no less capable or no less educated than those engineers who came out from the Ceylon University.

He also pointed out that in regard to the question of Voting Papers, the Council had placed many difficulties in the way of members and said that the Council should have followed the procedure of other Institutions of a similar status.

Mr. P. M. Sithamparapillai wished to know whether the Institution would advise the Government on post graduate qualifications obtained from abroad. The Honorary Secretary said that the Institution would do so if called upon by the Government.

Mr. T. G. D. Amarasinghe asked that since the Government has recognised the Diploma of the Institution, whether it meant that one has to pass all the parts of the examination to obtain Corporate membership.

The Honorary Secretary in replying to Mr. Maheswaran's inquiry regarding the Headquarters, stated that it was hoped to construct the building in stages and the cost of first stage would be about Rs. 5½ lakhs out of which the Auditorium would cost in the region of Rs. 160,000/-.

The President in replying to the question raised regarding the degree of Lumumba University stated that M.Sc. was not a post graduate degree. The M.Sc. was the first degree of that University.

In regard to the Diploma, the President said that one has to pass the exempting qualifications, and as an example he cited the case of Civils. One has to pass Parts I & II and thereafter the candidate is interviewed by a Panel after completing 3 years of practical training and responsible work.

There being no further comments, the President suggested the adoption of the Report be proposed and seconded.

Mr. Mathurunayagam then proposed and Mr. Amarasinghe seconded the adoption of the Annual Report. This was unanimously approved.

The President thereupon invited the Honorary Treasurer to present the Statement of Accounts for 1968/69.

The Honorary Treasurer explained briefly the Annual Statement of Accounts and drew attention to the Income & Expenditure statement and the Balance Sheet which was printed and included in the Transactions.

He also said the 'Balance Sheet' as might be observed showed a rather high amount as Excess of Income over Expenditure. That was due to the fact that the Government Grant for the previous Financial Year was received by the Institution at the beginning of the Financial Year under review. This was due to the delays in correspondence in connection with the increased Grant. He then explained the various items of expenditure as shown in the 'Income & Expenditure' statement and the 'Balance Sheet' and concluded by stating that he would be pleased to elucidate any matters raised by the members.

The President then announced that the Statement of Accounts was open for discussion.

Mr. T. G. D. Amarasinghe inquired whether the Institution could not be exempted from Income Tax.

Mr. P. M. Sithamparapillai stated that there was a large amount lying as excess of Income and asked whether it was not possible to transfer this to the Savings Deposit Account.

Mr. Mathurunayagam suggested the preparation of a monthly budget on the basis of which withdrawals could be made from the Savings Deposit so that more interest could be earned.

Mr. G. S. Sinnatamby stated that the accounts were in a fairly sound condition. An excess of Income over expenditure was noted in the General Account but however, in respect of examinations it was not so.

The President answering to Mr. Amarasinghe's inquiry stated that it was not possible to obtain exemption from Income Tax unless the Institution could be classified as a charitable Institution.

The Honorary Treasurer replying to Mr. Sithamparapillai's suggestion said that one reason that more money was not deposited in the Savings Account was that it was not easy to withdraw when required.

While thanking Mr. Mathuranayagam for his suggestion the Honorary Treasurer stated that owing to difficulties in budgeting and withdrawals etc. it appeared that the proposal was not easy to implement.

Replying to Mr. Sinnatamby's statement regarding the loss on examinations, the Honorary Treasurer stated that certain payments had to be made to the London Institutions for services undertaken the previous year in connection with examinations, hence the high expenditure reflected in the accounts for year ending 31st March 1969. The Balance sheet however would indicate that the holding of the examinations was by no means financially disadvantageous.

In the absence of further comments, Mr. G. S. Sinnatamby proposed and Mr. Amarasinghe seconded the adoption of the Statement of Accounts and it was unanimously passed by the House.

List of Office Bearers—The President then announced the names of the Office Bearers for 1969-70 which were as follows:—

President	—	Mr. A. MacNeil Wilson
Vice President	—	Mr. V. N. Rajaratnam Dr. S. L. de Silva Mr. T. Sivaprakasapillai Mr. B. R. P. Goonawardene
Members of Council (Fellows)	—	Mr. S. W. Peiris Mr. P. H. Perera Mr. G. D. Somasundaram Mr. L. S. de Silva Mr. L. Sydney de Silva Prof. J. C. V. Chinnappa
Members of Council (Members)	—	Mr. S. H. C. de Silva Mr. A. A. C. W. Jayasekera Mr. Sena Attygalle Dr. A. M. N. Amarakone Prof. U. S. Kuruppu Dr. M. S. Perera
Honorary Secretary	—	Mr. C. Rasiah
Honorary Treasurer	—	Mr. A. C. Wickramasinghe

The President said that before he gave up the reins of office, he would wish to thank the Members of the Council for the co-operation and assistance given him during his tenure of office. He had done his best in discharging his duties as President. He also said that the decisions taken by the Council were always unanimous and he hoped that the decisions taken were correct and in the best interests of the Members and the Institution.

He then thanked the Honorary Secretary and the Honorary Treasurer and the staff of the Institution for the hard work they had put in and giving him all the assistance in the discharge of his responsibilities. He also thanked the Press Supplement Committee which did a good job of work in bringing forward the Supplement in two of the papers, and specially Mr. P. H. Perera who did most of the hard work. He also thanked Mr. D. Abeysundera, Administrative Secretary of the State Engineering Corporation for all the good work done by him in arranging the Hall and the Authors who presented valuable Papers at the Sessions.

The President expressed his thanks also to the following: The Chairman of the National Textile Corporation for the permission granted to visit the Thulhiriya Integrated Textile Mill; The Chairman of the Ceylon Broadcasting Corporation and the Press for the publicity given to the Annual Sessions; the Dinner Dance Committee and finally the Director of Irrigation for affording the use of the Auditorium and to the officers who made the necessary arrangements and is particular to Mr. P. H. Perera. He then called upon Mr. A. MacNeil Wilson, the new President to take the Chair.

Mr. MacNeil Wilson on taking over, thanked the Council and members for electing him President and for the confidence they had shown in electing him to that very high office. He accepted that position with great pleasure. He added that he came to Ceylon over 27 years ago and that he had been a member of the Institution for over 20 years.

Continuing, Mr. Wilson said that he and the newly elected Council would do their best and ensure that the Institution and the Engineers would get due recognition in Society.

On behalf of the Institution he expressed a very sincere vote of thanks to Mr. Kulasinghe for the hard work he put in during the previous year. He wondered how Mr. Kulasinghe with so much official duties found time to attend all the meetings of the Institution and always came prepared as he was never searching for papers. Furthermore, the President said that the Institution was most fortunate to have had the guidance of Mr. Kulasinghe and he was most grateful to him for all he had done for the Institution.

The President then said that the next item in the Agenda namely the election of Auditors will be taken up and called for nominations.

Election of Auditors

Mr. T. D. G. Amarasinghe proposed and Mr. M. Mathurunayagam seconded the re-election of the present Auditors, M/s. Satchithananda, Schokman, Wijeyaratne & Co. for the ensuing year.

This was accepted by the House.

Amendments to By-Laws

The Honorary Secretary stated that they were printed in advance in order to save paper and time pending approval of the House. He said that in regard to the first resolution, the amendment had to be made as the existing By-law was not satisfactory. The second resolution became necessary for the Council to take speedy and effective action and it had therefore to be amended.

The Honorary Secretary then moved the following amendment to By-Law 76:

> "All payments from the funds of the Institution shall be effected by order of the Council by means of cheques signed by the Honorary Treasurer and counter-signed by the President or in the absence of the President, by a Vice President. The Treasurer shall obtain receipts in respect of all such payments".

This was seconded by the Honorary Treasurer and unanimously carried.

The Honorary Secretary next moved the following amendments to By-Law 84:

> "The Annual General Meeting shall be held in the month of October or at such convenient time as may be fixed by the Council, at such place and at such hour as may be appointed by the Council, to receive and deliberate upon the Report of the Council on the state of the Institution with the Annual Statement of the Accounts and the report of the Auditor thereon, to receive a report on the election of the Council and to appoint an Auditor and to confirm any resolution duly passed by the Council for any new By-Laws or Regulations or for the alteration or recession of any existing By-Laws or Regulations or for any other specific purpose or purposes relating to the direction and management of the concerns of the Institution. Notice of the Annual General Meeting shall be given not less than twenty-eight clear days before the date fixed for the meeting, and shall be sent to each Corporate and Non-Corporate Member. Twenty Corporate Members shall be a quorum at an Annual General Meeting".

This was seconded by the Honorary Treasurer and approved by the House.

Any other business

Mr. K. L. T. S. de Silva said that he had handed over a resolution to be presented at the Annual General Meeting, but the Honorary Secretary said that it was not in order as notice of such resolution had not been given.

Mr. Kulasinghe recommended that the matter be left to the Council to take whatever action that was necessary.

Mr. A. S. de Silva suggested that the Institution take the question of obtaining Library books free of FEECs as the Education Department was already moving in the matter.

Mr. Kulasinghe said that the Council would press to get the books FEECs free.

Mr. M. Muthubalasuriyar informed that the Institution of Electrical Engineers, London, had exempted its members from FEECS in respect of subscriptions. He suggested that the Honorary Secretary take up this matter with the Civils and Mechanicals. The Honorary Secretary stated that he would pursue this matter.

Mr. T. D. G. Amarasinghe inquired whether the Corporate Members who are not Chartered Engineers will get the Diploma of the Institution and whether they will be accepted in Government Service.

Mr. Kulasinghe explained that there was a little confusion over that matter. All those who are qualified to be Corporate Members of the Institution under the official regulations introduced after 1957 are eligible to be called Chartered Engineers and are entitled to get the Diploma of Corporate Membership. Those who do not qualify for Corporate Membership will not be called Chartered Engineers and will not receive the Diploma.

Mr. D. T. Jayamanne then asked what would be the intrinsic value of being a Fellow or Member of the Institution. Could any Fellow or Member get a suitable job in Public sector or must they have the British qualifications to get a job?

The President said that the Institution has obtained recognition by Government. He added that obviously every Member or Fellow of the Institution may not have the necessary qualifications which will be recognised by Government as some were elected under the old regulations. The point he wished to make was that the standards laid down by the Institution had to be built up for the future as well. to be on par with International standards, so that there would be no need to go outside Ceylon to obtain those qualifications.

There being no further questions the President declared the Annual Sessions closed.