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Is your research really necessary?*

by J. D. McIntosh, MSc, AMICE, AMIStructE

Contribution by T. W. Parker, MSc, PhD, FRIC

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Mr McIntosh's paper deserves serious thought and discussion. The construction industry expends notably little on research in comparison with other industries It would be a singularly unfortunate situation if the journalistic title adopted for the article led to the assumption that even the little attempted could safely be reduced.

Research expenditure as a percentage of net output in 1958 was estimated to be as follows.†

All manufacturing industries	3·8%
Chemicals	5·9%
Non-electrical engineering and shipbuilding	1·8%
Aircraft industry	35·7%

In comparison, the research expenditure compared with gross output of the construction industry (in 1965) is about 0·4%; this can be further sub-divided into approximately 0·5% for research expenditure on materials as a proportion of the value of material production, and 0·3% as a proportion of research costs on other than materials to the gross output of the construction industry less the estimated value of materials used‡.

It can perhaps be argued that the need for concentration upon research in a traditional industry is different both in kind and in order of expenditure needed compared with those of relatively new industries. In particular the latter, having been started from the results of scientific research, may need to continue with a more massive research effort. However, the discrepancy between 0·4% and the national average of 3·8% remains so great that one can reasonably make the modest conclusion that the construction industry must continually lag behind the development which is being attempted by industry as a whole.

The more useful exercise in Mr McIntosh's case would surely be to speculate upon what kind of research and development might become possible if the industry more nearly approached the national average. Note that, in terms of actual expenditure, this would involve increasing the effort from the present estimated £14,600,000 to about £145,000,000. Very obviously neither the industry nor the research and development element of it could safely announce programmes which would be sensible, of maximum utility, or practicable for so large an increase to take place rapidly. It is rather a question of a steady expansion towards this target and the latter part of Mr McIntosh's article gives a start to this, if it is regarded as suggestions for additions to, rather than substitution for, the existing programme. His suggestions would then presumably about double the size of the present effort.

Within the existing effort, criticism that what is being done is not always of direct benefit to the industry

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* Pages 179 to 184 of *Magazine* No. 57.

† Information from Advisory Council on Scientific Policy Annual Reports 1961, 1962. *Industrial Research in Britain*— Central Office of Information, 1961.

‡ Research and development expenditure taken from *Review of Research and Development for the Construction Industry*, MoPB&W, 1965: gross output of the building industry 1965 taken as £3,851,000,000; estimated materials used taken as £1,591,000,000.

should, I suggest, be treated with caution. A proportion of reported research must necessarily relate to work being carried out for postgraduate research degrees. In these, the important factor is that the postgraduates should be trained in research and in the scientific method. Good training in research as a professional activity is more important than the applicability of the results of whatever project is attempted to immediate constructional problems. It does not follow that the solution of some immediate problem will provide adequate training in research methods or philosophy and any research supervisor of postgraduate students should give first place to the latter, if necessary at the expense of the former. Further, many research schools have only limited means to perform any research at all and may well be limited in the choice of subjects which they can tackle expertly. Finally, there is a strong argument that research which generally widens the boundaries of building science and technology should have a place in any expenditure on research, even though its results cannot be specifically applied to one or other limited short-term problem.

In summary, however limited the money available for research in the construction industry, some proportion of it should be expended on items which do not necessarily link closely with some specific present or forecasted future need of the industry. We are here, of course, considering the whole field of total national research in construction. The research part of some individual firm may be much more closely correlated with its special problems. But such research is likely to have value only if the firm has secured trained research workers to undertake it.

Within the field of materials and structures research, work on cement and concrete has always held a fairly prominent place. It is possibly the item which attracts the highest proportion of effort within the building field. It would be interesting if Mr McIntosh could supplement his already imaginative article by one considering the directions a considerable expansion of cement and concrete research might take as an addition to, rather than a substitution, for that now in hand.

Contribution by G. P. Chapman, BSc, PhD

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In examining his question, Mr McIntosh criticises large areas of research and points his finger in the direction of apparently useless projects. However, his assessment of the value of certain work may be dangerously wrong.

It could, of course, be argued that no research is really necessary because most things will eventually be found out anyway—in practice. But the length of time and the uncertainty of 'chance' development makes a large amount of research desirable. It is the speed of development and industrial competition which make certain projects essential. Coupled with this need is the requirement for the discovery of materials and technology to make the research development possible. Therefore the necessity of research is governed by the urgency of obtaining knowledge.

But all research is not done because it is really necessary. A large amount is legitimately carried out simply because it is desirable. It is a matter of looking ahead to anticipate problems before they become urgent and solve them before they become crises. So, if your research is really necessary, then it has been started too late.

On the other hand, the desirability of research must surely be measured in terms of value. What Mr McIntosh really asks is: "Is your research of any value?" Furthermore, in answering his question, he seems to reach the conclusion that much of the research in the concrete industry is of little value. This is difficult to believe and perhaps the answer really lies in his wrong assessment of value.

Value is inevitably measured in terms of money, but it is a hard fact that research workers are not very good at understanding high finance. Also, the practical men are not very good at assessing the value of research. Therefore research comes out of the argument fairly badly. For instance, it is easy to choose a topic which has had concentrated research and to say that this concentration is unjustified. It may well be that the research was, in fact, very valuable, but the people looking at it were not capable of assessing its real value.

For example, lately in this country a large amount of effort has been put into the study of the behaviour of double curvature arch dams in concrete. In particular, five universities were employed to solve similar problems using different methods. The critics have been provided with ample ammunition. Why has so much money been spent on this research in a country where there is never likely to be a need for this type of structure, and why so much duplication? The fact is that the problem arose from the consultants' offices, a large proportion of whose work is overseas, providing considerable revenue, some of which has been ploughed back into seeking more efficient and economic design procedures. If the research had revealed that presently used methods were the best, then that alone would have been sufficient and valuable information in itself. However, the new techniques and data produced will easily repay the cost which was put into them. Furthermore, many men will have gained extremely useful research experience and no doubt a

number of PhDs will have been awarded. And why not? These men are responsible for new technologies—a fact which is soon forgotten.

I believe that these men and their teams are typical of the research profession and that the number of 'wasters' is no more than in any other walk of life. It is foolish and dangerous thinking to imagine that luxurious academic research exists for its own sake. It is doubtful in fact whether it exists at all. The critics must strengthen their case. They would be hard put to it, for instance, to list as many as ten specific, useless projects relating to the concrete industry.

Technical advisers inevitably rely on their own judgement and opinions based on experience. But surely it is better that opinion should be replaced by fact, and this can only be found by systematic investigation in the form of research.

Reply by the author

Both contributors have commented on the title of the paper: I accept Dr Parker's reference to its being journalistic and that the analogy to the wartime slogan about journeys may suggest that the need for research effort was being questioned. However, I hope that the paper made it clear that my concern is over the type of activity and distribution of interest rather than over-indulgence in luxurious academic research.

My interest is primarily in concrete research but I also accept that it is appropriate to consider research in the construction industry in general, as Dr Parker has done. If the industry could find more money for research activities, it might be appropriate to think in terms of doubling the amount of research effort in our research institutions. But I would want much of any extra money available to be spent on increasing the technical personnel in the industry so that the results of research could be used much more effectively. At the present time, I doubt whether there are anything like enough technical people in many of the productive parts of the industry to absorb the research output with even the present low proportion of expenditure on it.

The value of research can be assessed in a general way by discovering what people will willingly pay for it. The productive parts of the industry (or Dr Chapman's 'practical men') are fairly shrewd at recognizing the value of certain things when their effects are explained, but in general they do not willingly pay large amounts towards research projects. They may not be good at assessing the value of research, as he suggests, but equally research workers may not be good at helping them to recognize the value of their work. Either way the research appears to be lost to the industry and, accordingly, research expenditure for the industry, as a percentage of output, remains low.

My main concern is not so much whether a piece of research is useless but whether any use is made of it and whether we spend enough time in thinking about the possible value to others of what we have set out to do. The industry must be able to afford some work which is not of immediate and direct benefit to it and much of this will be undertaken in the universities. But the calibre of the rest of research elsewhere is largely in the hands of people who have been through our educational establishments, whether with postgraduate research degrees or not; I therefore support Dr Parker's emphasis upon the training in research and scientific method that should be given to postgraduates. Training in assessing the relevance of one's work may be as important as training in the way to do it.

Having made these comments, I hasten to add that I believe that the main reason for the low proportion of research effort in the construction industry lies in the fact that it is basically a 'one-off' industry rather than a mass-production industry. As a result, a very high proportion of design and construction effort has to be devoted to considering the environment in which the particular structure will be placed, and the proportion free to take advantage of the results of research is correspondingly low. However, the mass-production sections of the concrete industry in particular are not necessarily responsible for the initiation of a high proportion of research effort, although I believe that much benefit would accrue if they were.

In the paper, under the heading 'Potentialities of concrete', I have already hinted at a number of types of concrete research activity which could well be followed whether resources increase or not. As cement is the cheapest manufactured chemical we have, it can probably accept treatment processes, normally thought to be expensive in a constructional context, if the properties are thereby modified considerably. But research would have to be freed from the inhibitions of the preconceived ideas of concrete used as an engineering material. I hope the following will be useful amplification.

I mentioned, on page 182, the use of short fine wire reinforcement in concrete: a number of people are studying the use of other fibres, such as asbestos, glass and synthetic textile fibres as a means of controlling the internal stresses in concrete. I have not heard of any attempts to produce hydrated cement fibres: I can well imagine that hydrated cement paste could be produced so that it had a much greater strength and E value in the form of filaments than in the mass. Cement fibres should be fairly durable, compatible with concrete and probably not very expensive, and development might well lead to a new technology with many new applications for concrete.

Much of the cement in concrete remains as unhydrated clinker and this is a relatively heavy and expensive form of aggregate. I do not believe that we have made much progress in increasing the efficiency with which we can use cement. A recent review of Russian work[8] suggests that the strength of a neat cement paste can be more than doubled by the use of ultrasonic vibration—presumably hydrated cement is removed from the surface of the cement grains as soon as it is formed by an action similar to that exploited when the process is applied to the cleaning of jewellery. Few people seem to have taken seriously Abrams's 50-year-old claim[9] to have produced 'concrete' with a cylinder crushing strength of 40,000 lb/in^2: modern technologies should help us to do better than this. High-strength concrete may well have other desirable properties apart from strength.

In the structural field, problems of preventing excessive deflexion have been becoming more acute and greater emphasis could be given to determining how a member occupying a given space and carrying a given load can be made appreciably lighter; at present, a large proportion of structural concrete is not in critical parts of the members and could be replaced by lighter material. The use of openings and cavities in the members could be developed further, particularly with very-high-strength concrete which does not have a much higher density than concrete of ordinary strength. I believe that aerated concrete and lightweight-aggregate concrete are just a beginning in making use of the potential value of air wrapped up in concrete !

If a recent paper[10] stimulates designers in general (not necessarily structural designers) to consider ways in which concrete can be used in the development of new products, it is likely that there will be many intriguing projects which, if successful, could be of considerable benefit and bring the concrete industry nearer the mass-producing industries so that it would be natural to devote a higher proportion of gross output to research and development.

The details of reference 7, which were not available at the time of going to press, are now appended.

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