The work done in compressing elastically the top surface of a slab of concrete subject to uniform bending moment would be of the same order of magnitude.

It was clear that, with the simply supported slabs which the Author had described, the work done elastically on the concrete and the steel would be considerably less than those small amounts of 75 lb.-inches and 0·3 lb.-inches respectively, so that it was a fair deduction that the work done elastically was negligible. Although Mr. Vivian had ventured to criticize the Author's theory, he wished to express his appreciation of the valuable experimental work described in the Paper.

The Author, in reply, observed that, as Mr. Vivian had stated, energy was expended chiefly in plastic deformation as the reinforced concrete beams and slabs deformed to final failure (see comments on *Fig. 1*). The results, however, indicated that a reduction factor obtained from considerations of an elastic beam was a " rough average " of the experimental values, at least over the limited range of the experiments, and its use led to a reasonable estimation of the impact strength of the test beams and slabs.

He would like to point out that the crushing of the concrete under the load referred to by Mr. Vivian was due to failure of the beam in bending, and it would seem from the *Figs. 5* that the damage was very nearly identical under both static loading and impact.

With regard to Mr. Vivian's Table giving the numerical differences in the energy absorbed under static loading and impact, the Author would like to repeat that in tests 3 and 4 the failure of the concrete units was different under the two loadings and the equation $\alpha\ WH = A_s$ should not be used. Those cases did therefore represent a breakdown in the suggested method of predicting impact strength.

It was interesting to note that no indication of the recorded low impact strength of " mild " steels 3 and 4 was given by Mr. Vivian's rough estimate of energy absorption values derived from his method of strain analysis.

Paper No. 5437.

" The Maintenance of Plant used for Civil Engineering Construction."†

By Thomas Basil Smith, Stud. Inst. C.E., and Reuben Winton Bell, Assoc. M. Inst. C.E.

Correspondence.

Mr. W. H. Kelly observed that the Paper had drawn attention to the fact that on occasions serious danger to personnel might arise. It was

† J. Instn Civ. Engrs, vol. 23 (1944–45), p. 179 (Feb. 1945).

not uncommon to find cranes without any visible indication of the safe working loads and radii, others where longer jibs had been fitted without the load radius indicator having been amended, and still others where the minimum quantity of ballast was not accurately known. He suggested that (1) the jibs and masts of such cranes should be permanently marked with safe working loads and radii; (2) the backstays should be marked with the correct weight of ballast and the size of the holding-down bolts.

It was very important that rope replacements should be made with ropes of the same size and breaking strength as those originally fitted by the makers. Owing probably to the necessity for keeping weights as low as possible, the drums and pulleys were usually of the minimum permissible diameter. A slightly larger rope had the effect of disproportionately increasing the bending stresses, so that the factor of safety might be seriously reduced and premature or sudden failure might result.

Most excavators were supplied with attachments which made them into multi-purpose machines. The dragline jib or boom was usually long and slender and of lattice construction. The investigation of several mysterious failures of those components indicated that when being transported or dismantled they had been mishandled and slightly kinked, that that had escaped notice, and that when at work the boom had suddenly doubled up. The greatest care should be exercised when handling such booms to avoid any distortion.

Mr. F. L. King observed that the Paper contained much material for thought by civil (and other) engineers who might have, in future, to set up some type of plant maintenance scheme.

As Plant Superintendent of the London Midland and Scottish Railway, he had had to develop and operate a similar organization, covering all the plant used by the Civil Engineering Department, and whilst he would endorse the broad concepts set out by the Authors, he suggested that in some respects suggestions needed either considerable modification or clarification.

In particular, he considered it inadvisable to refer to preventive and remedial servicing as if they were completely different operations: lubrication and cleaning were operators' responsibilities, and as such were the responsibility of the using engineer, but all adjustments and repairs should be considered as " skilled attention " and be the responsibility of the Plant Engineer. Only mechanics under his sole jurisdiction should be allowed to deal with such matters; the using engineer should call upon the Plant Engineer, whenever, and wherever, plant showed signs of giving unsatisfactory operation.

A log book should be allocated to each separate machine and this should show by daily entries all stores consumed, work upon which the machine was engaged, and a signed statement by the repairing mechanic of attention carried out to the plant.

A history sheet for each machine should be kept in the office, and should

show all labour and material costs involved in maintaining the machine, together with the cumulative costs, as a knowledge of the rate of increase of those costs with age was of vital interest to the Plant Engineer.

Regular " hours run periods " should be fixed for inspection and/or overhaul of various sections of the various machines, but code letters and figures for those should be avoided : the average man did not like working to such codes and they lent themselves to misinterpretation.

Instructions should be concise and clear, and should be incorporated in the log book, where that could be done ; the instructions for lubrication should include a diagram showing the position of every lubrication-point ; those charts should be provided by the makers of the machines. The suggestion to ring with " coloured paint " on the machine the oiling points was, in most cases, impracticable, because a number of such points just could not be coloured, or could not be clearly seen even though coloured.

The records kept should be as concise as possible, avoiding the collection of a mass of information which, although at first sight needed, was, in fact, useless for deciding matters of maintenance. For example, every visit of a mechanic was of interest, as indicating the reliability or otherwise of the machine, but only details of actual major repairs and replacements of parts needed to be recorded ; too much small detail could easily cloud the vision and tend to prevent clear cut decisions regarding total replacements of machines.

Repairing mechanics should be carefully selected from ordinary fitters, as only men with a genuinely inquiring mind were suitable ; they should be gradually taught by precept and example a certain amount of theoretical engineering in connexion with plant, in order that they might be able to diagnose troubles in the early stages. Petrol engines, Diesel engines, electric generators, electric welding machines, and air-compressors, for example, were machines in common use by construction gangs to-day, but the essential differences between them were such that ordinary fitters were not qualified to deal with their various and varying symptoms ; only men who could work reliably without repeated checks by an inspector were of use on plant work.

Without exception a test of every machine after every adjustment or repair should be carried out, and the result should be recorded.

Where repairs were carried out at site, the test would be, generally speaking, a period of work under observation by the repairer, who should report the results to the Plant Engineer.

Where repairs were carried out in the depot a machine test under " Laboratory conditions " should be carried out and the test-sheet should contain all the instrument readings recorded during the test. That test-sheet should be examined by the foreman so that he might, if necessary, ask the repairing mechanic questions regarding various " practical " matters ; when the foreman was satisfied regarding the general reliability of the repaired machine, the test-sheet should immediately be submitted

to the Plant Engineer, who would examine the test figures from the theoretical and practical angle, to be sure that the performance of the machine was up to its rated standard. If approved, the test sheet should then be signed, and only then should permission be granted to dispatch the machine to site work. That procedure was a very good check on the repairing mechanic's work; it avoided the necessity for inspectors to be constantly around the machines under repair, and it avoided disputes between workmen of roughly equal position.

The Authors in reply stated that they fully agreed with Mr. Kelly's remarks on the marking of items of plant with such important information as safe working loads. They had also found it particularly useful to have each item marked with slinging and lifting points (indicated by a painted arrow and the words " Sling Here ") and, where applicable, with pneumatic tire pressures.

The " clarification " of points such as " hours-run inspection " had been made by the Authors and was only absent as a result of abridgment of the Paper; a full specimen set of servicing instructions for a concrete mixer was included in the original text and clearly showed the division of responsibility between the operator and the mechanic.

Experience had shown that the lubrication charts provided by manufacturers were often either incomplete or inaccurate and that it was better to prepare charts to a standard layout, with cross references to the servicing instructions for the machine, and in every way suitable for the maintenance system being used.

The Authors were in full agreement with the necessity for very careful selection of " repairing fitters " and with the importance of working tests after making adjustments, etc.

Paper No. 5462.

" Charing Cross Railway Bridge: Temporary Repairs to Damaged River Span."†

By Eric Kenneth Bridge, B.Sc., Assoc. M. Inst. C.E.

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Mr. P. S. A. Berridge observed that the decision to use 50-foot spans appeared to have restricted the use of cranes operating from the railway on the Surrey side. Had the spans been 25 feet long it seemed likely that the time of 15 weeks, taken to restore traffic over two tracks across the 154-foot gap, might have been shortened very considerably. He realized

† J. Instn Civ. Engrs, vol. 23 (1944–45), p. 188 (Feb 1945)