TRANSPORT-COMMUNICATIONS

MONTHLY REVIEW

MARCH 1955—No. 95

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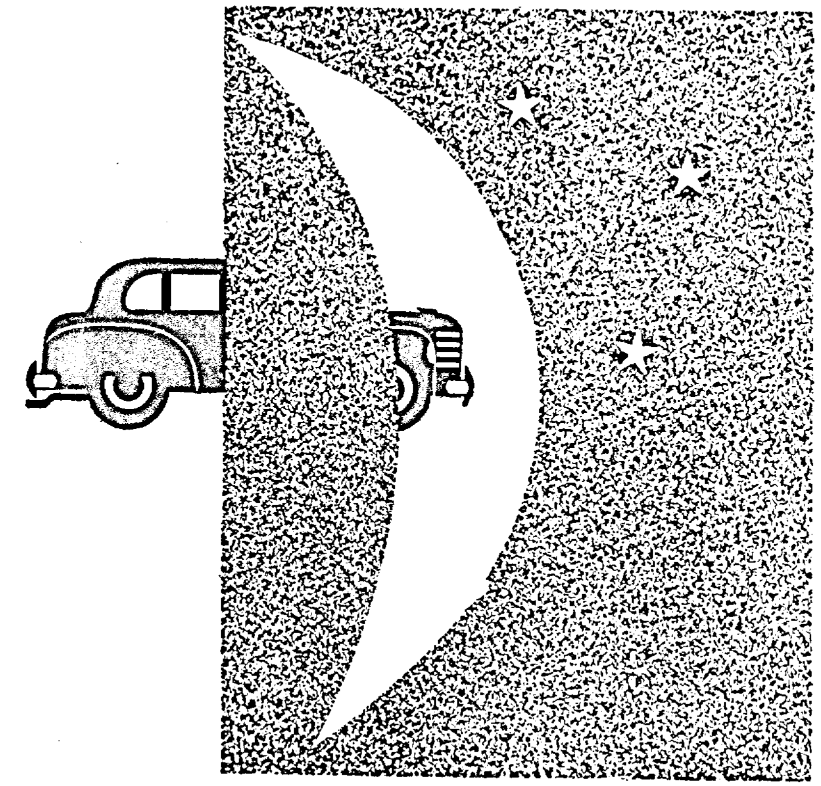

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CONCRETE SURFACING IN AGRA-BOMBAY ROAD—
MADHYA PRADESH

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

MARCH 1955

BENEFITS OF GOOD ROADS

QUICK and easy communication between communities, states, and nations is one of the greatest forces in modern civilization. This applies to the transportation of passengers, freight, and the mails, and to the transmission of telegraph and telephone messages. The public roads constitute that part of the transportation system which comes closest to all the people in their daily life, both in the town and in the country. The country, however, is most affected, because the public road is the sole means of transportation when we leave the boat landings and the railroad and inter-urban stations. The country people are entirely dependent on the road to connect them up with all the rest of the world. Hence, if we wish the benefits of modern progress and civilization to be enjoyed by all, both in the town and in the country, we must provide good public roads.

It is hardly possible to make a list of all the benefits of good roads, but the following are among the most important. It may at first appear that many of these items are repetitions of the others, but a more careful analysis will show that each is sufficiently distinct to warrant separate mention.

1. Good roads decrease the cost of hauling everything.

2. Good roads save the "bad road tax".

3. Good roads allow a wider choice of market for farm products, and for purchasing supplies.

4. Good roads permit choice of time for marketing products, so as to get the best price.

5. Good road building furnishes a useful and profitable market for large quantities of material that would otherwise be without value.

6. Good roads allow the hauling to be done when other work is impossible.

7. Good roads allow greater production with a given number of men and teams.

8. Good roads increase the area which may be devoted to raising high-priced commodities.

9. Good roads permit and encourage diversification in crops.

10. Good roads tend to equalize the business on the railroads and in the towns, and thus keep market prices stable, and business conditions more uniform.

11. Good roads assist co-operative buying and selling.

12. Good roads permit the use of better stock and better vehicles.

13. Good roads increase the value of land everywhere.

14. Good roads induce tourist travel in all parts of the country.

15. Good roads invite more people and more investments in every line of development.

16. Good roads tend to increase the rural population.

17. Good roads conserve the farmer's energy, both mental and physical, and give him greater initiative to conceive and execute plans for development.

18. Good roads make possible the rural mail delivery.

19. Good roads promote good schools in the country and make the town schools more accessible to the country children.

20. Good roads promote better living conditions in the country.

21. Good roads improve the social conditions in the country.

22. Good roads make possible the work of the "social centers" and other similar movements.

23. Good roads tend to unify the population by taking the town people to the country and the country people to town.

24. Good roads make for a broader outlook and a better citizenship in every phase of life.

(From "Bulletin of the Agricultural and Mechanical College of Texas"— July 15, 1917)

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

LEVELLING: The operation of ascertaining the relative elevations of different points with reference to the assumed level of a known or fixed point. The mean sea level is often assumed as the datum level if this not otherwise specified.

LONGITUDINAL SECTION: The outline of a vertical section usually along the centre line.

OBSTACLE TO MARRIAGE

One great obstacle to marriage these days is the increasing difficulty in supporting the government and a wife on one income.

Sign on top of Grand Coulee Dam: "U. S. Government property; do not remove."

THE USE OF GROUNDNUT HUSK IN SOIL STABILIZATION

By 67

S. R. MEHRA AND L. R. CHADDA

Introduction

USE of soluble binders like molasses, lignin and different types of resin have been tried with varying success in soil stabilization. It has been noticed that incorporation of small percentages of such binders with graded soil considerably improves its physical characteristics Large scale application of these binders for stabilization of earth roads will ultimately depend upon their availability near the site of construction at a reasonable cost. Due to the limited supply of binders like lignin and the more profitable alternative use of molasses for the manufacture of power alcohol, these cannot be had cheap enough for use in soil stabilization.

Investigations were carried out in the Laboratory at Karnal to make use of groundnut husk (a waste product in groundnut oil industry) in soil stabilization for road construction. Groundnut husk used in the experiments had the following composition !

Moisture	15.0	Per cent
Fibrous matter	68.5	,,
Resinous matter	16.0	,,
Others	0.5	,,

The above composition was determined by extracting of the resinous matter from the husk with hot water.

Conversion of Husks into a stabilizer

Groundnut husks when treated with hot water yield nearly 16-18 per cent of a reddish brown resinous matter.

This water soluble resinous mass as such has no stabilizing property and it washes out slowly on coming in contact with water.

The extraction of the resinous mass can be accelerated by treating the husk with 1 per cent Sodium Hydroxide solution. Complete extraction is possible by allowing the husk to remain in contact with an alkaline solution for 3-4 days and then filtering it. Even the sodium derivative prepared as above has no stabilizing effect on soil and it is highly soluble in water. But when treated with calcium chloride the formation of an insoluble gelatinous mass which acts as an excellent binder in improving soil characteristics, is formed. A detailed study has been conducted with this stabilizer (calcium derivative) for its use in soil stabilization and results obtained are presented in this note.

The effect of increasing percentages of this stabilizer has been tried on four typical soils occurring in the Punjab. The following characteristics of the resultant soil mixtures have been studied:

1. Density.
2. Resistance to the softening action of water.
3. Abrasive Resistance.
4. Tensile strength.

Physical characteristics of the soils selected for the study are given in Table I.

Table I

Physical Characteristics of the Soils Selected for the Study

Soil No.	Type of Soil	Liquid Limit	P. I.	Sand content per cent	Optimum moisture per cent	Total solids per cent	Exchangeable Na & K me*	Bases Ca me*
1.	Sandy loam	23.9	6.4	62.0	12.0	0.04	3.32	4.2
2.	Silty loam	29.4	10.2	11.2	11.0	0.08	3.18	7.0
3.	Silty clay loam	38.0	16.0	9.4	11.0	0.04	2.88	14.8
4.	Loam	26.14	9.75	43.0	11.0	0.06	3.34	8.7

The stabilizer extracted from the husks was used in the form of a solution. After conducting a large number of experiments it was found that the maximum concentration of the stabilizer (Calcium derivative) that could be obtained from the groundnut husks using one part of husks and 10 parts of 1 per cent alkaline solution, varied from 2 to 3 per cent. For all practical purposes it was taken as 2.5 per cent. Concentration of calcium chloride required to separate 2.5 per cent of the stabilizer from 100 c. c. solution was found to be 1.5 gm.

Effect on density

All the four soils mentioned in Table 1 were mixed with increasing quantities of the dark brown alkaline solution extracted from husks and the mixture was dried. After drying to constant weight different quantities of calcium chloride dissolved in water representing optimum moisture of each soil was added and compacted in a compaction apparatus at 40 strokes of 5½ lb sliding weight. Quantity of soil used in each set of experiments was 200 gm. The blocks were dried to constant weight in an oven at 50 C and the density of each soil block was determined. The results obtained are given in Table II.

Table II

Density of Soils mixed with Increasing Percentages of Stabiliser

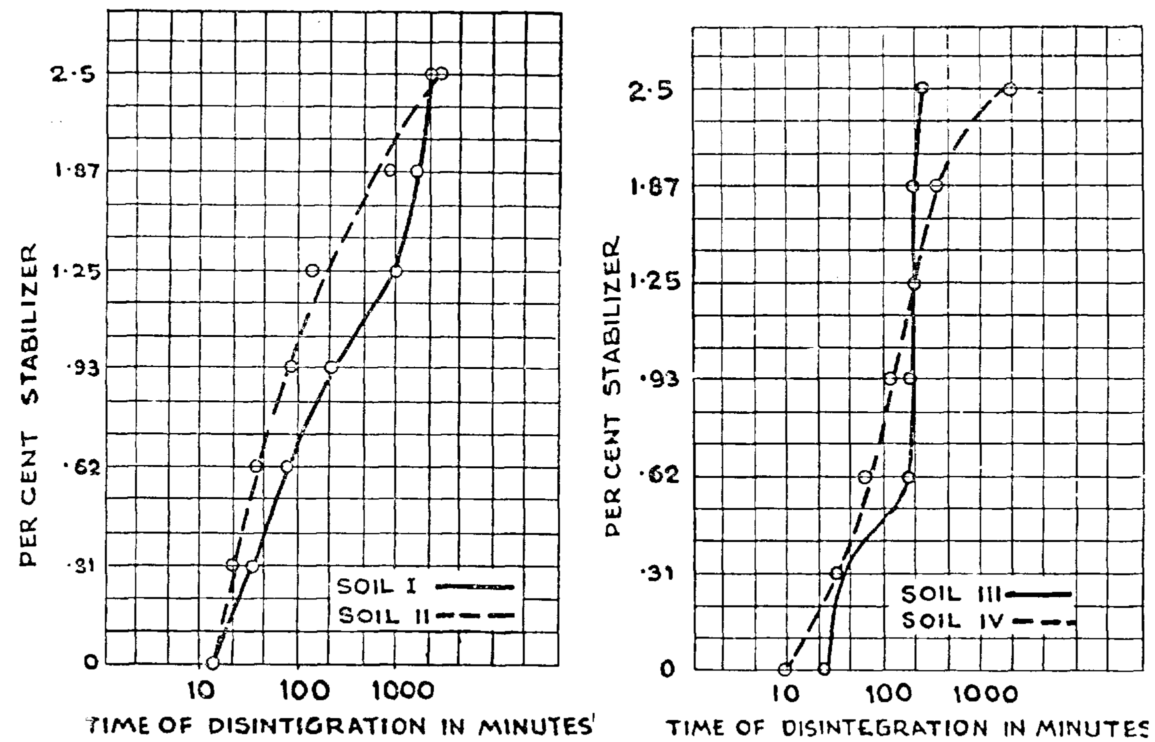
S No.	Stabilizer Per cent	Ca Cl_2 Per cent	Density			
			Soil 1 Silty loam	Soil 2 Silty loam	Soil 3 Silty clay loam	Soil 4 loam
1.	0	0	1.93	1.891	1.97	1.857
2.	0.31	0.125	1.96	1.84	1.95	1.91
3.	0.625	0.25	1.94	1.87	2.0	1.858
4.	0.937	0.375	1.96	1.86	1.92	1.870
5.	1.25	0.50	1.92	1.86	1.91	1.85
6.	1.875	0.625	1.93	1.86	1.91	1.86
7.	2.50	0.75	1.92	1.81	1.85	1.89

* m = mille equivalent.

It will appear from Table II that the addition of the stabilizer produced hardly any change in the density of the soils tested.

Resistance to Softening Action of Water

The blocks used for the determination of density were submerged in water at 25° C. and the time of complete disintegration recorded. Results obtained are given in Table III and reproduced in figure I.



Effect of Husks Stabilizer on the Water Resistance Quality of Soils.

Fig. 1

Table III

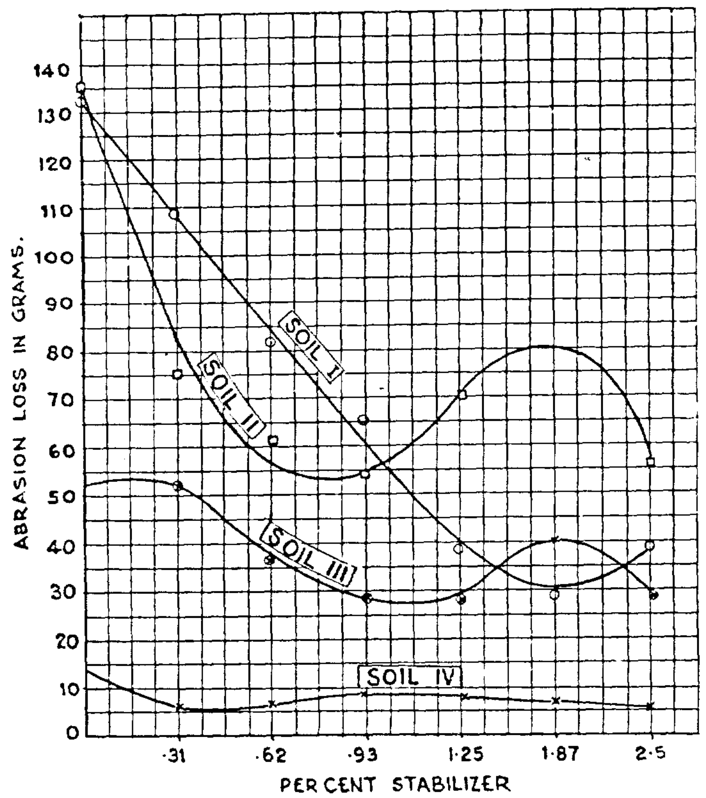
Effect of Increasing Percentages of Stabilizer on the Water-Resisting Quality of Soils.

S. No.	Stabilizer Per cent	Calcium Chloride Per cent	Time of disintegration in minutes			
			Soil 1 sandy loam	Soil 2 silty loam	Soil 3 Silty clay loam	Soil 4 Loam
1.	0	0	15	15	25	10
2.	0.31	0.125	32	23	30	32
3.	0.625	0.250	65	36	186	63
4.	0.937	0.375	198	95	160	108
5.	1.25	0.500	1160	145	190	195
6.	1.875	0.625	1454	780	205	330
7.	2.50	0.750	2670	2400	250	2160

It will appear from Table III that with the addition of stabilizer all the four soils considerably improve in resistance to the softening action of water. Maximum effect is produced in soils 1, 2, & 4. The stabilizer is more effective with soils having high sand content.

Abrasive Resistance

Blocks of all the four soils weighing 200 gm were prepared at optimum moisture with increasing percentage of the stabilizer as described earlier. These blocks were subjected to abrasion in a Dorry type abrasion machine. Results obtained are given in Table IV and presented in figure 2.



Effects of Husks Stabilizer on the Abrasive Resistance of Soils.
Fig. 2

Table IV

Effect of Adding Increasing Percentages of the Stabilizer on the Abrasive Resistance of Soils.

S. No.	Stabilizer per cent	Calcium Chloride per cent	Loss due to abrasion in gms per square inch area of contact after 1000 revolutions			
			Soil 1 sandy loam	Soil 2 Silty loam	Soil 3 silty clay loam	Soil 4 loam
1.	0	0	*133.5	*135.3	14.4	51.7
2.	0.310	.125	108.6	76.2	6	52.2
3.	0.625	.250	82	61.8	7	36.6
4.	0.937	.375	66	55.2	8	28.8
5.	1.250	.500	39	70.8	7	27.6
6.	1.874	.625	30	80.4	7	40.0
7.	2.500	.750	39	57.2	6	29.4

* (The whole block abraded in less than 1000) revolutions.

It will appear from Table IV that with the addition of the stabilizer, abrasive resistance of all the four soils increases appreciably. Maximum effect is produced in soil No. 1. This beneficial effect of the stabilizer, points to its suitability for improving the service value of stabilized soil roads.

Tensile Strength

Due to the gelatinous character of the stabilizer it may affect the cohesion of soil and lead to an increase in shear strength of the compacted soil mass.

With a view to investigate this, standard briquettes for testing tensile strength using increasing percentages of the stabilizer with all the four soils, were prepared at optimum moisture. These were dried in the oven at 50°C and tested for tensile strength. Results obtained are given in Table V.

Table V

Tensile Strength of Soils Mixed with Increasing Percentage of Husk Stabilizer

S. No.	Stabilizer per cent	Calcium Chloride per cent	Tensile strength lbs/per sq. inch			
			Soil 1 Sand loam	Soil 2 Silty loam	Soil 3 Silty clay loam	Soil 4 loam
1.	0	0	105.0	143.0	230.0	133.5
2.	.31	.125	144.5	129	242.0	146.50
3.	.625	.25	148.5	130.5	218	131.0
4.	.937	.375	141.0	137.0	175.0	129.5
5.	1.25	.5	145.5	135.5	192.5	117.0
6.	1.874	.625	147.5	141.0	...	118.0
7.	2.5	.75	148.5	146	222.5	115.5

It will appear from Table V that the effect on Tensile Strength is not very pronounced.

Field Application

Due to the high cost of the husks, low yield of the stabilizer, and the complicated process of extraction, the use of groundnut husk for stabilization on a field scale may not prove to be economical. For a mile length of stabilized soil road (10 ft wide) about 1400 maunds of husk will be required if a 1.5 per cent concentration of the stabilizer is used and this will cost Rs 2800/- at Rs 2/- per maund at mill-site. It is doubtful if the advantage gained is compatible with the extra cost.

Summary

The effect of mixing a stabilizer prepared from groundnut husk on the characteristics of alluvial soils has been studied. Results show that the abrasive resistance and resistance to the softening action of water are appreciably improved by the addition of this stabilizer. But the cost as compared to the advantage gained is rather high and so its use is uneconomical.

Acknowledgement

Shri B. P. Kapur, Research Assistant has assisted the Authors in the investigation.

SOME PROBLEMS INVOLVED IN DESTRUCTIVE AND NON-DESTRUCTIVE TESTING OF CONCRETE

THE Paper surveys some of the problems associated with the testing of concrete by destructive and non-destructive methods.

The destructive tests considered are the compression test, the flexural test and the equivalent cube test. The relation between the strength of test specimen and the strength of the corresponding structure is discussed. It is suggested that the flexural strength test has distinct advantages over the compression test for road and runway construction.

Concrete may conveniently be tested in situ by an ultrasonic pulse method in which the velocity of an ultrasonic pulse is measured. The application of the method to the testing of structures and of concrete slabs enables an estimate to be made of the quality of the concrete.

Introduction

The "Strength" of concrete is normally taken to refer to the compressive strength of works or site cubes. The results of tests on these cubes do not necessarily indicate the quality of the concrete in the structure because the degree of compaction and the nature of the curing are likely to be different in the two cases. Nevertheless, the cube compressive strengths are very useful in that they give a measure of the uniformity of the concrete being produced and, since the making and testing of the cubes are carried out in a standard manner, they give also an indication of the potential strength of the concrete in the structure.

In addition to the information given by the cube compressive strengths, the engineer may wish to know the quality of the concrete in the structure itself.

There are two ways of dealing with this problem. One is to cut cores, beams or other specimens and to test these for strength; the other is to use non-destructive methods of testing the concrete in situ. The cutting of cores is mainly of value in studying roads, runways and other pavements, and enables direct determination to be made of the thickness of the slab, the compaction of the concrete and the position of any reinforcement. The compressive strength of the concrete can be measured by crushing the cores after they have been suitably capped. On the other hand, the drilling and capping of cores is a comparatively slow and expensive operation, and the slabs have to be made good after the cores have been removed. Beams are sometimes cut from concrete slabs, especially runway slabs, but this is an even more difficult and expensive procedure than drilling cores.

A number of non-destructive methods of test have been developed which do not require the cutting of test specimens. They generally measure the elastic properties of the concrete rather than its strength. The test which appears to have particularly useful application involves measuring the velocity of an ultrasonic wave pulse through the concrete. This method is inexpensive as regards time and labour and provides an easy method of comparing the quality of concrete in the structure and in the corresponding test cubes. The test generally requires that two opposite faces of the structure should be exposed and available; it is not easily applicable in its present form to paved areas. It is, however, particularly suitable for testing reinforced concrete columns, beams, walls, and other structures, prestressed structures, and precast units including reinforced and prestressed units. It also provides a practical means of studying the variation in quality of concrete throughout a structure and of following the increase in strength with age or the deterioration caused by destructive agencies such as frost or seawater.

Destructive Testing

The Compressive Test

In many circumstances concrete does not fail as a result of imposed loads but fails because of continued weathering, abrasion or rough usage. In such cases a test is required to indicate the general quality of the concrete, and the compressive test is commonly used. The specimens for this test are easily made and tested, the result being closely related to the water/cement ratio, which largely determines the durability, and there is a great fund of experience based on the compressive test.

It must be emphasised, however, that the compressive strength measured by uniaxial loading of cubes or cylinders is not a fundamental property of the concrete. The load at which failure occurs is influenced by factors such as shape of specimen, end restraints and rate of loading. Thus, the compressive strength of the concrete in a structure, under conditions obtaining in that structure, will differ from the compressive strength of a cube, although the quality of the concrete may be the same. For example, it is well known that the compressive strength of a cylinder 6 in. by 12 in. is about three-quarters of that of a 6 in. cube. This is not due to any difference in the quality of the concrete nor to any buckling effect, but arises because a given compressive load produces different stress distribution in a cube and in a cylinder of the same cross-sectional area.

In general, the conditions in a structure will be such that a given load per unit cross-sectional area is more likely to cause failure than in a cube, and therefore a factor of safety of up to 1.5 or 2 may be required to offset the effect of shape, end restraint and rate of loading. This margin is additional to that required to cover inferior materials, overload and similar contingencies.

The influence of test conditions on the failing load in compression tests is due to the complex mode of failure of the specimens. Experimental evidence shows that the initial cracks in concrete specimens are parallel to the direction of the applied load and are in the nature of a tensile failure. The load at which the cracks occur depends upon the stress distribution and they have been detected at about 30 per cent of the failing load in cubes and at 50 per cent in cylinders. Once the cracks are established all normal considerations of stress analysis cease to be applicable and Cown[3] has suggested that, thereafter, the concrete resembles "more and more a granular mass relying on internal friction for its strength". Within the region of failure the stress at which deformation proceeds remains constant, and there is considerable curvature in the stress-strain relation immediately before failure.

Near the top and bottom of the specimen the outward movement of the particles is restrained by the friction between the end faces of the specimen and the platens of the testing machine. This results in a pyramidal or conical portion of the specimen remaining intact and free from cracks at each end of the specimen; the remainder of the specimen falls away. Thus the ends of a cylinder with a height/diameter ratio of two or more have little restraint upon the fracturing of the central portion of the specimen. In the case of shorter specimens the effect becomes considerable and a greater load can be sustained. It is because of this effect that conversion data are given in B. S. 1881 : 1951 for estimating the equivalent strength of a standard cylinder from the observed strengths of cores with various height/diameter ratios.

Even though the compression test does not provide a true measure of the failing strength of structural concrete, it has proved extremely useful as a means of controlling the quality of concrete as mixed. It is also useful for comparing different concretes and has enabled mixes to be designed for specific purposes.

Improved methods of controlling concrete quality have thrown into prominence a factor which had previously been unsuspected, namely, variation in the performance of testing machines.

Compression Testing Machines. The essential requirements of a compression testing machine are that it should apply a uniformly distributed load to the surface of the specimen and that the increase in load or, alternatively, the increase in deformation of the specimen, should proceed in some specified and controlled manner. B. S. 1881 includes certain requirements, notably a limit to the surface irregularity of specimens and platens, the provision of a spherical seating and the use of a specified rate of increase of stress but these requirements may not always be sufficient. Plane surfaces of the specimen, plane platens and a spherical seating do not necessarily ensure a uniformly distributed load and in some cases machines fulfilling these requirements have been observed to produce markedly non-uniform loading. The fault appears as a relative tilting of the platens, always in the same direction; the deformation of the specimen is greater on one side than on the other and the observed strength may be 10 or 12 per cent lower than if it were correctly determined. It appears that although a spherical seating will initially accommodate any lack of parallelism of the loading surfaces of the specimens, the friction under load is too great to allow any subsequent movement. Thus, if, as a result of poor alignment or a symmetry of the frame of the machine, some distortion of the machine occurs, the spherical seating does not counteract this and a non-uniform load is developed.

The British Standard calls for a constant rate of increase of stress of 2,000 lb per sq in. per minute, but neither this nor a constant rate of increase of strain is easily achieved.

In all hydraulic machines the inlet valve should be gradually opened, or the pumping accelerated as the cubes approach failure in order to maintain the specified rate of increase of stress. Under these conditions some cubes in some machines fail suddenly, with a clean end-point, whilst in other cases cubes yield continuously and sustain their maximum load when the machine fails to compress the cube at a sufficient rate to continue the rise in stress. In such cases the rate of increase of stress falls relatively slowly from the specified value to a negative one and the maximum load recorded may depend to a considerable extent on the capacity of the pump in the machine.

The Flexural Test

In pavements, the concrete is required to withstand both tensile and compressive stresses, and failures occur either in direct tension or in bending. A direct test cannot conveniently be carried out on concrete and therefore it is logical that the flexural test, in which the beams fail as a result of the tensile stresses, should be adopted. The use of the flexural test is not yet widespread in this country and it is unlikely to become widely used as a control test until specifications for concrete call for a minimum flexural strength. It has been pointed out in a previous paper[3] that the use of flexural strength for specification and mix design purposes might well effect economy in road and runway work and its use is therefore to be encouraged.

The flexural strength of concrete is a manifestation of its tensile strength, which is a more specific property than the compressive strength. It is easier to determine the flexural strength than the direct tensile strength, but the value obtained is about twice the true tensile strength. This is largely because the derivation of the simple beam formula used in calculating the modulus of rupture is based on the assumption that stress is proportional to the strain, which is not applicable to concrete. The interpretation of the result of a flexural test is more straight forward than that of a compressive test, but it is attended by a number of problems, some of which have been discussed elsewhere[4].

The ratio of the length to the depth of the specimen affects the result since the simple beam formula is strictly applicable only to long thin beams whereas concrete beams used for the test are comparatively short and deep. The effect of this is to produce low results when beams are tested under third-point loading and high results when they are tested under central loading. The magnitude of the effect can be estimated by mathematical stress analysis. Moreover, under central loading the beam necessarily fails at or near the mid-span, whereas under third-point loading it may fail anywhere between the two planes of application of the load. In many cases the middle section between these two planes will not be the weakest section, and therefore the observed strength will, on the average be lower.

The rate of application of load has an appreciable effect on the observed flexural strength, which increases linearly with the logarithm of the rate of increase of load. The reason for this effect is not clear, but it undoubtedly involves the mechanics of failure and creep effects.

The size of specimen, method of loading and rate of loading have all been standardized in B. S. 1881 and this makes the test useful for purposes of comparison and control. The loading conditions in a structure, however, will, in general, differ in a number of ways from those in a test specimen, and the effective modulus of rupture of the structure will not normally be equal to that of the test specimens. The presence of these effects must be appreciated although they may be covered by a factor of safety, as in the case of compressive strengths.

The Equivalent Cube Test

A further test that should be mentioned is the equivalent cube test, described in B. S. 1881 and carried out on portions of beams which have been tested in flexure. The test enables both flexural and compressive strengths to be obtained from the same specimens and it has been found at the Building Research Station, the Road Research Laboratory and elsewhere that the results of equivalent cube tests are, for practical purposes, equal to those of tests on cubes, of the corresponding size. Results of individual equivalent cube tests may be more variable than those of tests on cubes, but the average of the results of two equivalent cube tests on one beam has a lower standard error than the results of a compressive test on one cube.

Non-destructive testing
The Ultrasonic Pulse Method

The method which shows most promise for testing concrete in situ is based on the measurement of the velocity of propagation of an ultrasonic pulse in the concrete. The pulse is propagated between a pair of quartz crystal transducers held on opposite faces of a structural member; a modification of the technique is used when only one face is available. The velocity of propagation of the pulse, i.e., the longitudinal-wave velocity, is calculated from the time of transmission of the the pulse and the path length between the transducers. The electronic apparatus, general technique and laboratory applications have been described elsewhere [1, 5, 6, 7] and the following discussion is devoted to their application to testing concrete in situ.

Longitudinal-wave velocity as a criterion of the quality of concrete. A basis for the method was provided by comparing the longitudinal-wave velocity with conventional standards of quality such as density, compressive strength of cubes and modulus of rupture of beams.

It has been shown that the longitudinal wave velocity is related to the strength of the concrete, provided that the aggregate/cement ratio, type of aggregate and moisture content remain the same.

For a particular type of concrete with constant mix proportions changes of density or strength due to variable compaction, differences in water/cement ratio, ageing or deterioration can readily be detected.

Application to the Testing of Concrete In Situ. An accurate assessment of the quality of concrete in situ can be derived from measurements of the longitudinal-wave velocity only if details of the concrete mix are known. There is, however, a large differencce between the wave velocity in well compacted and badly compacted concrete, whatevêr its composition, and such extremes are easy to detect. Leslie and Cheesman[8] in Canada have attempted to subdivide the range as a result of their tests on dams. Results obtained on structures in Great Britain have not been in agreement with the sub-division suggested and it has been found that the minimum wave velocity in concrete of acceptable quality varied appreciably with type of concrete and with type of structure.

Structures. The technique is well adapted to study the variations in quality of concrete in a structure, as given by the variations in the longitudinal-wave velocity. For example, when a portion of a structure shows visible signs of deterioration the question arises as to the soundness of the rest of the concrete. Whitehurst [9] has reported tests of this nature in which the sound areas of concrete were located within a structure which had deteriorated badly. Andersen and Nerenst [10] have made tests of a similar nature, using a condenser-chronograph apparatus, to study surface deterioration of a concrete structure after a fire. Also, one of the authors (R. Jones) has demonstrated how inversion in high-alumina cement produces concrete of variable quality when placed in lifts thick enough to allow an excessive rise in temperature to take place. [7] Other applications of the pulse technique have included the location of a volume of porous concrete in a prestressed beam, and the detection of concrete which had deteriorated badly in a subway.

When the mix proportions of the concrete are known, the longitudinal-wave velocity can provide more information about the quality of the concrete, especially if test specimens from the placed concrete are available. Under such favourable conditions, the equivalent strength of the concrete in the structure can be determined. The experimental technique employed has been to measure the longitudinal-wave velocity and compressive strength of cubes, taken from the placed concrete and tested at different ages. In this way the graphical relation between longitudinal-wave velocity and compressive strength was obtained for the actual mix used in the structure. Subsequent measurements of wave velocity, on the structure itself, were converted into the equivalent compressive strength. This procedure eliminates the effect of all factors which influence the relation between longitudinal-wave velocity and strength with the exception of the presence of reinforcement, and the drying of the concrete in the structure. The former rarely presents any difficulty since a direct path in the concrete can usually be found in all but the most heavily reinforced structures. When the position of heavy reinforcement is not known, the transducers should be moved in small steps of about 1 in., so as to detect any systematic variations in the wave velocity [7].

The loss of moisture by the structural concrete prior to test presents quite a serious difficulty in the interpretation of the wave-velocity measurements. In an attempt to overcome this difficulty the cubes cured under site conditions before they were tested. This, however, is not a satisfactory solution since the standard compression test refers specifically to wet cubes, and allowing the cubes to dry out gives somewhat anamalous results.[6] It is, of course, possible to allow for the drying of the concrete if the reduction in wave velocity is known. Experiments have indicated that the effect is likely to be small since the decrease in wave velocity over a period of 132 days in $32 \times 3\frac{3}{4} \times 3\frac{3}{4}$ in. beams was about 1 per cent for a mix with an aggregate/cement ratio of 4 and a water/cement ratio of 0.39, and 4 per cent for one with an aggregate/cement ratio of 9 and a water/cement ratio of 0.68.[4] A structure usually has a much lower surface area per unit volume than the beams tested and would therefore dry out at a slower rate.

A more exact procedure, which has never been tried in practice, would be to stack a spare batch of cubes near the structure so as to give a good approximation to its surface area per unit volume. The ratio of the wave velocity in the cubes immersed in water and used for calibration purposes, to that in the cubes cured under site conditions, would provide the factor for adjusting the wave velocities measured on the structure before estimating the equivalent strength. If no allowance is made for the drying of the structure, then the equivalent strengths will be under-estimated. This probably accounts for the results obtained on two occasions when cubes, cut from structures, gave compressive strengths 10 to 15 per cent higher than those predicted from wave-velocity measurements.

The results of tests made on structures show that the relation between the equivalent compressive strength and the

compressive strength of the test cubes varies considerably with different classes of construction. Under well controlled conditions, where the concrete is well compacted, its equivalent strength approaches that of well made test cubes. When the control is poor and compaction inadequate, then the quality of the placed concrete falls considerably below that of the test cubes. Results from an average type of construction gave equivalent strengths of from 36 to 68 per cent of the test cubes.[11]

Concrete road slabs. By varying the distance between the transducers the ultrasonic pulse technique can be used to determine both the longitudinal-wave velocity and the slab thickness by measuring the time taken for the ultrasonic pulse to pass to the bottom, be reflected and return to the surface. In practice the method is difficult to apply and it is only since a new transducer material, barium titanate, became available that success has been achieved.[12] Preliminary results have given an accuracy of about 10 per cent in the measurement of the thickness when the underside of the slabs is fairly even. Where the underside is very rough, there is no well defined reflection, and the method will not work.

An alternative method used for determining the wave velocity only has been to measure the time taken for the pulse to traval a known distance at the surface of the concrete. This method is not satisfactory because the measurements refer only to the surface layer and give no indication of any variation of compaction with depth. Even in well compacted concrete, measurements from transducers held vertically on the concrete have shown a discrepancy of about 5 per cent relative to cores cut from the slabs. The discrepancy appears to be linked with the presence of the upper surface but as yet no completely satisfactory explanation has been found.

Another form of test being investigated is based on the propagation of low-frequency vibrations in the slab. A theory for dispersion effects in a free slab has been given by Lamb[13] and an extension allowing for the presence of the subgrade, has been given by Pickett.[14] A satisfactory experimental technique has now been devised and it is hoped that the method will be applicable to slabs which are too rough to be measured by the ultrasonic reflection technique.

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(Continued on page 24)

GENERAL DESIGN CONSIDERATIONS OF FOUNDATIONS SAFE BEARING CAPACITY SETTLEMENTS

General

All foundations settle under load and the general tendency is for some parts of a structure to settle more than others, causing relative movements. The design should provide for foundations which serve to keep these relative movements within limits to which the superstructure can accommodate itself without harmful distortion. At the same time total settlements should be so restricted that these movements do not interfere with the purpose of the structure or damage connections to the structure such as drains, pipe lines, etc.

Foundation design, therefore, requires an appreciation of the various types of ground movement from which excessive settlements can result, such as the magnitude, character, and distribution of the loads transmitted to the foundations by the superstructure and structures in its immediate vicinity, the influence of the structure as a whole in redistributing these loads following slight relative movements of the foundations and its ability to accommdate itself to relative movement without dangerous overstress.

Types of ground movemen

Movement of the ground may result from the following causes :

(1) Immediate local failure in shear of the ground beneath the foundations.

(2) Slow plastic movements of soft strata whereby gradual lateral displacement from beneath the foundation takes place.

(3) Consolidation settlement due to expulsion of water or air from the voids of the soil.

(4) Movements independent of load considerations, such as shrinkage of clay soils, frost heave, and those due to unstable slopes, swallow-holes, and mining subsidence.

Shear failure

Prevention of failure of the soil in shear is a prime consideration in design.

Maximum safe bearing capacities. To guard against shear failure, bearing pressures should be kept down to values appropriate to the type of soil. Safe bearing capacities are indicated in Table 1. This Table assumes that the soil conditions at the site are fairly uniform and that the type of soil persists to a great depth beneath the foundations. More accurate indications may be obtained by tests on samples or by loading tests.*

Soft underlying stratum. If a soft stratum exists below the proposed foundation level, the foundation pressure should be restricted so that the net loading intensity at the level of the soft stratum does not exceed its safe bearing capacity.

Effect of adjacent cuttings, excavations or sloping ground. Cuttings, excavations, or sloping ground near to and below foundation level may increase the possibility of shear failure. Their effect should be investigated both when the cutting or excavation exists before the structure is built and when they are to be made subsequently. If the probable failure surface intersects a retaining wall or other revetment, this should be made strong enough to resist any unbalanced thrust.

The possibility of future deep excavation on adjoining sites should not be overlooked.

If there is any doubt as to the stability of the natural slope or cutting, the structure should be kept well back from the top of the slope or the slope should be stabilized.

(See Code No. 1: Site Investigations.)

Inclined strata. Inclined strata, particularly if they dip towards a cutting or basement, may aggravate the tendency to shear failure, and it may be necessary to carry foundations down below possible slip planes.

Plastic movements in soft strata

If a site is underlain by soft plastic clay, movements due to a gradual lateral displacement of the soil from beneath the foundations may take place even when the pressure is appreciably less than that likely to cause sudden shear failure.

Consolidation settlements

Consolidation settlement is an important feature of the foundation behaviour of clays and silts whereby long-continued settlements due to the gradual expulsion of pore water may take place under loads appreciably less than those proding the maximum safe bearing capacity of the soil.

Whereas with structures built on sands and gravels the settlement is likely to be practically completed at the end of construction, when the site is underlain by clays or silts settlement is likely to continue for a long time after construction. Distortion of the structure tends to increase with time and cracks may appear many years after completion.

With clays or silts the total settlement which may ultimately occur will depend upon the thickness and compressibility of the layer and upon the additional loading to which it will be subjected. The greater the thickness of the layer, the greater will be the total settlement and the greater the relative settlement. Both total and relative settlements are likely to increase with increasing stress on the layer. If the layer varies considerably in thickness and in settlement properties over the area of the building, relative settlements may be greater.

In such cases the loading to be placed on the foundations should be judged by :

(1) A study of settlement records of nearby structures having essentially the same foundation conditions.

(2) Consolidation tests on undisturbed samples and an analysis to indicate the probable magnitude, rate, and distribution of the settlements of the structure.

Movements independent of load

In some cases soil movements may result from changes not concerned with load considerations, arising from such factors as seasonal shrinkage and swelling, loss of ground due to removal of fines by pumping, change of ground-water level, application of artificial heat or cold, or the presence of swallow-holes or underground workings.

Limitations of test loading as final criterion

The bearing capacity of an individual footing, pile, pier or caisson may be ascertained by test loading, but this does not check the collective strength of the site. The engineer should check the possibility of any general deep-seated failure. It should be noted that settlements recorded in connection with loading tests will give no criterion of the probable movements of the full-scale structure.

FRUIT, TOURISTS & POTATOES

It is proposed to widen the existing road in order to take two-way traffic.................which is very essential in view of the growing heavy traffic on account of fruit, tourists, and potatoes.

From a Project Report

(Extracted from the British Standard Code of Practice "Foundations")

PRECAST FERRO-CONCRETE CONSTRUCTION IN FRANCE*

DURING the course of the past five years, precast ferro-concrete construction in France has made considerble progress, and, for various reasons now appears to be in general use. It possesses the following advantages :—

(1) A saving in shuttering by the use of a reduced set of moulds, solid and accurate.

(2) A simplified form of shuttering; for instance there is a considerable difference between a portal built **in situ**, and the same one cast flat on the ground or, preferably on a concrete floor where only lateral shuttering is necessary, and recoverable a short time later.

(3) No need to search for highly skilled carpenters, often so difficult to find nowadays.

(4) The actual pouring of the concrete need not take place on scaffoldings; strains, especially at great heights, are detrimental to the accuracy of slender frameworks.

(5) The various concrete members can be cast in the most suitable positions so as to ensure best quality concrete. For instance, thin vertical slabs can be cast flat on the ground.

(6) Special treatments (steam, vacuum, vibrations) can be more easily applied.

(7) The concrete members can be readily tested at ground level and the factor of safety of a series of similar elements ascertained with accuracy.

(8) It is possible to obtain dense and homgeneous concrete members of accurate dimensions and in perfect uniformity.

(9) The weight of the concrete members can be reduced, either because of the increased quality of the concrete which warrants higher stresses, or as a result of tests which can limit the factor of safety to a relatively low value.

(10) Supervision at ground level is easier to carry out, and the chances of accidents very much reduced.

(11) Weather conditions do not affect the work since it can be carried out under cover. During frosty days, the concrete can be poured in warm and closed sheds, whilst in hot weather the work can proceed under cool and shaded conditions.

(12) The time of construction can be reduced. For instance, the various members of the superstructure can be prepared in anticipation, during excavation and foundation work.

(13) The work can proceed during daily stoppages caused, for instance, by tides or traffic interruptions, and even during seasonal stoppages caused, for instance, by floods or continuous frosty periods in cold climates.

(14) The various grades of labour can be utilised in the most appropriate manner.

(15) And finally, the work can be prepared and organised rationally, thus increasing efficiency.

In short, prefabrication helps us to cross over from the handicraft stage to the mass production of the various components involved.

Yet, it has its drawbacks; it demands more elaborate designs, and it can only

(Continued on page 29)

* Paper read before a Joint Meeting of the Institution of Structural Engineers and the British Section of the Societe des Ingenieurs Civils de France in London November 11th, 1954.

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HERE AND THERE

1. ANCIENT MONUMENTS IN THE WAY

HIGHWAYS have fallen so low in the Government's regard that almost anyone can obstruct their improvement.

Gloucestershire County Council wish to widen the King John Bridge at Tewkesbury. This is scheduled by the Ministry of Works as an ancient monument, and the Ministry say it must not be touched. The county surveyor told the highways committee that the bridge had very little merit except its age. He said it had been added to and crudely repaired in the past, and had lost any beauty it once had. The bridge is an eyesore. What is more important it carries heavy traffic.

Delhi is no exception. It has numerous ancient monuments. The much needed improvement to roads in order to ease the growing congestion is oftentimes vetoed by an odd ugly monument. In other words, traffic improvement suffers from ancient monuments in Delhi.

(Adapted from 'The Surveyor'—8th January, 1955).

2. IS VERGE PART OF A ROAD?

IN a case **Rodgers V. Ministry of Transport and Another**, heard in 1952, an action was brought for an injunction and declaration by an owner of property nearby in order to prevent the Ministry of Transport, U. K., from providing a lay-by. The Court refused the remedies sought, and the Lord Chief Justice, in his judgment, held that the verge was part of the highway and that lorry drivers were not doing anything illegal by leaving their vehicles on the verge during a temporary stop. The Ministry had not exceeded their powers by providing this lay-by, but had merely levelled or widened the road in accordance with the Highway Act.

(From Contractors' Record and Municipal Engineering — September 8, 1954.)

3. HINTS ON CARE OF TREES

Pruning

IN pruning, it is usual to work from the top of the tree downward. The worker climbs the tree and crotches his rope before making any cuts, except for the removal of unwanted branches or thorns which impede his climbing. Not only does this add to safety; it also speeds the work by permitting easier clearance of the cut branches as the work progresses downward.

Unless bleeding prevents the immediate application of wound dressing, flush cuts are usually painted at the time they are made.

In all cases, procedure must be varied to suit the purpose for which the pruning is being done. However, there are few exceptions to the following five simple rules:

1. Remove dead wood and broken branches.

2. Remove branches that grow straight upward, main stems excepted.

3. Remove branches that turn backward toward the centre of the tree.

4. Thin out interfering and closely parallel branches.

5. Take out suckers unless needed to renew an open space or to prevent sunburning of the bark.

It is not always practical to weigh too carefully the advantages and disadvantages of pruning at a particular season. There are, however, several important exceptions. Certain trees tend to bleed if pruned during the dormant season, so it is generally safer to prune these trees after they come into leaf. Dormant pruning tends to be followed by a long type of branch growth, whereas pruning during the growing season generally makes new growth more compact. Careful workers take advantage of this to obtain a desired type of growth. Dormant pruning is especially advantageous for sanitation work, in that during the lower temperatures and drier atmospheric conditions of winter, fungi have less chance to infect cuts.

Summer has marked advantages for clearance pruning. Workers can clearly see the degree to which the weight of foliage pulls down branches. Too many types of trouble which attack an occasional branch are most easily detected during the growing season because the withered or discoloured foliage directs the worker's attention to the need for removal.

Slowly healing ragged wounds provide easy entrance points for harmful insects and fungi. Therefore, in pruning, workers should strive to leave wounds which will heal rapidly. Cuts should be flush, so as not to interfere with normal sap flow.

Diseased Wood

Since much of the wood removed in pruning is diseased, some of these diseases may be transmitted to healthy trees by means of the pruning tools unless the tools are sterilized before making final flush-cuts, to which wound dressing should be applied as promptly as possible.

Diseased wood which has been removed should be burned or otherwise disposed of in a way to render it harmless.

(From 'Roads and Engineering Construction' September, 1954).

4. 14-INCH REINFORCED CONCRETE TRAFFIC BUTTONS FOR WIDE STREETS

● BY lane separations it was found it possible to control traffic on four very wide intersections in Boulder, Colo., that had given us trouble for years. The reinforced concrete traffic buttons not only delineate the lanes but discourage motorists from driving over them. We make the buttons, using for moulds reflectors from old-type street lights.

The buttons are 14 inches in diameter, and 4 inches high. A $\frac{3}{4}$ in. pipe nipple, 4 in. long, provides a hole through the centre of the button. They are set by pouring hot asphalt $\frac{1}{2}$ in. thick on the pavement and embedding the button. A $\frac{1}{2}$ in. by 10 in. lag screw is driven down through the centre into the street pavement. Only a hard blow by truck wheels can dislodge the button thus secured to the pavement. The buttons are spaced 4 ft apart and painted with traffic-yellow paint in order to make them more readily visible both during the day and at night.

(From 'The American City'-Jan. 1955.)

5. RESEARCH ON PRESTRESSED CONCRETE

● THE following is from the Report of the Building Research Board for the year 1953.

Impact Strength

The ultimate resistance of reinforced concrete beams to a single impact is superior to that of prestressed concrete beams provided that the reinforced beams are adequately reinforced with vertical stirrups. These stirrups appear to be almost as important as the main longitudinal reinforcement in influencing the impact resistance of reinforced concrete. Under repeated impacts, each insufficient

in itself to cause failure, prestressed concrete beams can have appreciably greater resistance than ordinary reinforced concrete beams with normal vertical steel.

Fire Resistance

Preliminary information based on tests made in Britain and the U. S. A. confirm that a fire resistance of two hours' duration can be achieved with little or no modification in design for simply-supported beams of 10 ft and 16 ft span with post-tensioned cables. Some of the results indicate, however, that further precautions may be required in the design of continuous beams. For longer periods of fire resistance, secondary mild steel or protective material may be necessary.

Static Strength

Research on the behaviour of prestressed concrete beams under static loading indicates that simple formulae are adequate for calculating the ultimate strength of normal types of section. In a few cases, however, there appears to be a need for more refined methods of calculation in which consideration is given to the conditions of stress and strain in the concrete and in the steel at failure.

Losses of Prestress

Laboratory measurements of the loss of stress due to creep of hard-drawn steel wire of the type used in Great Britain show that over a period of several years it may be between 6 and 10 tons per square inch for an initial stress of about 75 tons per sq. inch and between 4 and 7 tons per sq. inch for an initial stress of about 65 tons per sq. inch. Records of strain in the concrete of the main prestressed concrete beams of an office building show that one-and-a-half years after the initial stressing (which amounted to 60 tons per sq. inch), the stress in the steel had fallen by not more than 4 tons per sq. inch. Further shrinkage may be expected as the concrete dries out. Evidence from this and other structures suggests that other losses of prestress may be of as great or greater importance. Such losses may be caused by friction with long cables or by slip at anchorages with short cables, or by elastic shortening of the concrete when a number of wires or cables are stressed successively and not simultaneously.

Railway Sleepers

Static and dynamic loading tests have been made on prestressed concrete railway sleepers in which either plain wire or indented wire was used in the pretensioning system. Sleepers with plain wire failed, under static load applied near one end, as a result of slipping of the wire in the concrete. In similar tests there was no slipping of indented wire, and sleepers with such wire were some 15 per cent stronger than sleepers with plain wires. Eight sleepers were subjected to dynamic loading, and it was found that there was no significant difference in strength between the sleepers with the two types of wire.

(From 'Concrete and Constructional Engineering'—September, 1954.)

6. COLOURED CONCRETE SURFACES

● THE COLOURED AGGREGATES are glued to sheets of thin plywood which are placed in the shuttering so that the face aggregates are bonded to the structural concrete and the plywood is removed when the adhesion is destroyed by the water in the concrete. The surface thus transferred to the structural concrete is finished by wire-brushing, sand-blasting, grinding.

This process is known as the "aggregate transfer" method.

(From "Concrete and Constructional Engineers"—January, 1955.)

7. STANDARDISATION OF STRUCTURAL MEMBERS

WITH a view to reducing the cost of shuttering, the British Standards Institution has issued B. S. No. 2359, "Preferred Dimensions of Reinforced Concrete Structural Members". The recommended dimensions are as follows:

Cross-sectional dimensions of all members—6 in. rising in multiples of $1\frac{1}{2}$ in. to 15 in. and thereafter in multiples of 3 in.

Slabs—Length and width in multiples of 3 in.

Beams—Length in multiples of 3 in.

Column bases and foundation blocks—All dimensions in multiples of 3 in.

Square piles—Sides 10 in. in increments of 2 in. to 18 in. Splays at corners, $1\frac{1}{2}$ in.

Splays at junction of walls and floor of tanks and at junction of wall and base of retaining walls—Angle 45 deg.; distance from wall and base, a multiple of $2\frac{1}{4}$ in. so that the dimension of the slope will be 3 in. or a multiple of 3 in.

Column heads in flat-slab construction.—Splays 45 deg.; depth of splays in multiples of $2\frac{1}{4}$ in., but $12\frac{3}{4}$ in. minimum; depth of thickening of slabs in multiples of 1 in. but 2 in. minimum; width of thickened slabs in multiples of 6 in.; distance between column heads in multiples of 3 in.

(From "Concrete and Constructional Engineering"—January 1955).

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8. CONCRETE ROADS IN GERMANY

THE following notes are abstracted from a Paper by Dr. E. H. Graf in the American Journal "Rock Products".

The cement should be of good quality with a high content of Fe_2O_3 and moderate contents of Al_2O_3 and MgO. The fineness should be such that there is a residue of at least 5 per cent, on a sieve with 176 meshes per square inch. The initial set should occur in less than one hour at an air temperature of 95 degrees F. The cement should have a high strength in bending and little shrinkage on hardening. The cement should not be delivered until after its strength at seven days is known in order that it shall not be used as soon as it is made; shrinkage cracks have occurred as a result of using fresh cement in hot weather.

Cement and sand should be measured by weight. Coarse aggregate may be measured by volume. The concrete should be consolidated to as great a density as possible. Most of the variation in the strength of the concrete, as shown by tests of cores, is due to variable consolidation. In roads laid in two courses the concrete in the two layers should have the same strength and elasticity, and the top course must be laid immediately after the concrete in the bottom course.

The German specifications for roads require a compressive strength of not less than 5260 lb per square inch and a bending strength of not less than 640 lb per square inch. Cores taken from the road two months after it is laid must have a minimum strength of 4550 lb per square inch.

For slabs 8 in. thick laid in lengths of 100 ft, with two dummy joints in this length, 0.1 per cent of reinforcement is sufficient. In slabs about 300 ft long, 0.3 per cent of reinforcement in the middle third is considered to be necessary. Slabs more than 1200 ft long have been laid with various amounts of reinforcement. The German specification requires joints at intervals of 33 ft to 50 ft, although greater intervals are permitted in roads laid on firm bases and in districts where the climate is equable. The Author's recommendations are that in roads to carry heavy traffic the amount of reinforcement should be from 0.16 to 0.2 per cent and the slabs from 90 to 125 ft long. In the case of slabs 300 ft or more long on sand, about three times as

much steel should be used in the middle third. There should be twice as much reinforcement near the sides of the slab as in the middle, with $1\frac{1}{2}$ to 2 in. of cover, so as to prevent tensile stresses in the concrete.

The German motor roads are generally $8\frac{1}{2}$ in. thick, without thickened edges, and they have not been damaged by axle loads of $8\frac{1}{2}$ tons. Axle loads of 10 tons are now permitted; the Author doubts the wisdom of this increase because of the ill-effects of the repeated overloading of reinforced concrete slabs.

From "Concrete and Constructional Engineering"—January, 1955.)

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9. ACCELERATORS AND RETARDERS FOR USE WITH PORTLAND CEMENT

THE substances which cause modern Portland cements to set quickly are alumina and ferric oxides. Fine grinding also tends to quicken the setting time. Because of these factors cement would set much too quickly for practical use unless retarded, and the usual procedure is to add a little gypsum to the clinker, as it is being passed into the grinding mill for this purpose.

This, of course, is done by the makers, and if the user wants earlier strength than the normal cements give the commonest additive to use is calcium chloride. There is plenty of experience of using this material, either in flake or granulated form and provided the proper amounts are used and it is evenly distributed in the mix no harmful effects result. It has for a long time been thought that the calcium chloride could not be used for reinforced work because chlorides are liable to attack steel. Careful research has shown that, although very slight initial corrosion occurs, this does not progress with time. The normal amount to use is 2 per cent by weight of the cement, and in rough terms this will double the strength at one day. At three days there should be a 50 per cent increase, and at three months perhaps not more than 10 per cent. These figures apply to normal Portland cement, and the increases will not be so high if rapid hardening cement is used. However, it may safely be said that the addition of calcium chloride will increase the strength of a rapid hardening cement concrete by 50 per cent at one day. Calcium chloride increases the workability, and there is some increase in the shrinkage on hardening, most of which takes place in the first week. One of the greatest advantages of using this accelerator is that concretes can be placed at lower temperatures than is normally allowed. Thus rapid hardening cement concretes with calcium chloride added and placed at a temperature of 29° F. showed quite a good gain of strength in the first day, and at three days the strength was improving at about the same rate as that of ordinary cement concrete would at 64° F. The one precaution that must be carefully watched is not to use too much of this additive, since above 3 per cent there is a possibility of a flash set.

There are many chlorides which have an accelerating effect on the hardening of concrete; common salt, for instance, acts in much the same way as calcium chloride, but with less effect and less reliable results. In commercial preparations aqueous solutions of various sorts are often combined to obtain the desired effect. Among the materials so used would be alkali carbonates, aluminates and silicates or mixtures of various chlorides of calcium, magnesium and sodium. Care is needed in making these preparations, as there are many salts which are liable to cause either acceleration or retardation on set according to the amount used. However, calcium chloride is cheap and easily obtained in a suitable flake or granulated form for dissolving in the mixing water, and as this gives safe and satisfactory results with either normal or rapid hardening cement it is hardly necessary to look further. Some cements which have the correct amount of calcium chloride added are sold under proprietary names, and these are widely used for cold weather concreting or for obtaining higher early strengths.

Far and away the most important retarder is gypsum. It has already been mentioned that gypsum is added by cement manufacturers to the clinker before grinding so as to control the setting time which would otherwise be too fast. As, however, large quantities of gypsum cause slow expansion during the setting, the amount added must be closely controlled, and in cement manufacture it is usual to add an amount corresponding to about 1 to 2 per cent of sulphur-trioxide. Other retarders are plaster of Paris, which acts in much the same way as gypsum, but more vigorously and soluble anhydrite which acts similarly. Lime is also a retarder, but with a smaller effect. Retarders are not commonly needed by cement users, and those mentioned above are liable in different quantities to have a reverse effect so that they must be used with care. There is, however, one other class of retarders which is commonly used on construction work, and this includes the aqueous solutions based on sugar, which are generally applied to formwork to prevent the set at the surface of the concrete, which can then be rubbed or brushed to give a better key for plaster or expose the aggregate.

From 'Contractors' Record and Municipal Engineering' — September 8, 1954).

(Continued from page 15)

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(From a Paper by R. Jones & P. J. F. Wright-Symposium on Mix Design & Quality Control of Concrete, London, May 1954. Cement & Concrete Association.)

CURRENT LITERATURE

ABSTRACTS

U. D. C. No. 631.4 SOIL DENSITY AND STABILITY. Bulletin No. 93. Highway Research Board of the National Academy of Sciences, 2010, Constitution, Washington, D. C., December 1954.

THE bulletin contains the following 5 Papers

(1) Selection of Densities for Subgrades and Flexible-Base Materials.

(2) Relationship between Density and Stability of Subgrade Soils.

(3) Effect of Compaction Method on Stability and Swell Pressure of Soils.

(4) New Method for Measuring In-Place Density of Soils and Granular Materials.

(5) Effect of Repeated Load Application on Soil Compaction Efficiency.

The first Paper by Chester McDowell describes a realistic method for selecting densities comparable to the most-nearly ideal field conditions which can be obtained under practical construction methods.

Papers 2 and 3 present data to show not only how the limitations in density, water content, and degree of saturation influence stability but also how stability and swelling characteristics of soils are influenced by the method of compaction used. Some of the conclusions are given below.

The relationship between density and stability of soil depends on the criterion used to define stability: the greater the permissible strain before a sample is considered unstable, the greater is the possibility that an increase in density will cause an increase in stability.

For saturated subgrade conditions, the higher the density of the subgrade the greater will be its stability. However for partially saturated subgrades, the desirable density for maximum stability will depend on the water content of the subgrade and too high a density may have a deleterious effect on stability.

In designing and constructing pavements resting on partially saturated subgrades, the selection of the desirable density of the subgrade should be based on the anticipated maximum water content of the subgrade and the density versus stability relationship for the soil.

In methods of pavement design based on the results of tests performed on samples prepared in the laboratory it is desirable that the test samples should have the same properties as those of the soil compacted in the field. The method of compacting a soil sample in the laboratory has a significant effect on the resulting properties of the soil.

For the two soils investigated, a silty clay and a sandy clay, samples compacted to equal densities and water contents by kneading and impact methods do not show any large difference in stability as measured by a Hveen Stabilometer test. At lower degrees of saturation, samples prepared by kneading compaction have higher stabilities and at higher degrees of saturation, samples prepared by impact compaction have higher stabilities.

At lower degrees of saturation, samples of the two soils investigated prepared by static compaction have somewhat higher stabilities, in stabilometer tests, than samples compacted by kneading and impact methods to the same densities and water contents; at higher degrees of saturation, samples prepared by static compaction have much-higher stabilities than similar samples prepared by impact and kneading compaction.

The practicability and usefulness of the density method for specifying and controlling compaction has been further increased by the development of the Washington Densometer, described in "New Method for Measuring In-Place Density of Soils and Granular Materials."

The most-efficient compaction method is that method which requires the minimum number of applications of load and yet produces the required amount of work to densify the soil to meet requirements, according to a Paper by G. F. Sowers and C. M. Kennedy, "Effect of Repeated Load Applications on Soil Compaction Efficiency."

U. D. C. No. 631.4 SIMPLIFIED AIR-JET DISPERSION APPARATUS FOR MECHANICAL ANALYSIS OF SOILS by T. Y. Chu and D. T. Davidson, Iowa State College Engineering Report No. 21, 1954-55.

THIS Paper describes the development of a simplified air-jet dispersion apparatus. A comparison of this apparatus with three other dispersion apparatus, viz., (i) End-over-end shaking, (ii) A. S. T. M. Stirring apparatus, and (iii) Wintermyer soil dispersion cup, is also given. Results of mechanical analyses on a wide variety of soils indicate that the device gives a comparatively high degree of dispersion without causing significant degradation. This apparatus is simple in construction and, consequently, can be built at a relatively low cost. In addition, because of its unique design the procedure for its use is substantially simpler than that for other dispersion apparatus.

U. D. C. No. 388 HIGHWAY-USER TAXATION, Bulletin 92. Highway Research Board, 2101, Constitution, Washington, D. C., DECEMBER 1954.

THE bulletin contains three papers presented at the Thirty-Third Annual Meeting of the Highway Research Board.

"Objectives and Concepts of Highway User Taxation," by Richard M. Zettel, deals with objectives and concepts of highway-user taxation and some fundamental premises of the current theory of highway finance, including the relationships between highway finance and public finance generally.

User taxation is a convenient and workable method of financing a vital economic function which government must undertake. Fundamentally, the ground for user taxation is the public decision that highway finance should be governed by principles that apply in the private sector of the economy. User charges which bear a relationship to the costs incurred by government in supplying highway services are believed to be an acceptable means of financing the service which public policy dictates should not be financed through the general tax structure.

On the other hand, it may be argued that, regardless of the highway function and over and above recognized user tax obligations, special imposts on gasoline, on motor-vehicle products or in other ways bearing on highway users may be suitable as general revenues. In this event, the case for or against such taxes must rest squarely on criteria appropriate to evaluation of general taxes without reference to highways. Such taxes cannot be ruled out of consideration, simply because users are already paying highway charges.

It is concluded that a firm foundation, for user taxation can be established in economic and political theory which is consonant with current thought or general taxation.

"Estimate of User Taxes Paid by Vehicles in Different Type and Weight Groups," by Edwin M. Cope, John T. Lynch, and Clarence A. Steele, discusses the amount of state highway-user taxes paid by vehicles of different types and size groups in America.

"Gasoline Consumption, Weight and Mileage of Commercial Vehicles," by Robley Winfrey presents a summary of monthly mileage, gross vehicle weight, and gasoline consumption for eight models of single-unit trucks and three models of tractor-semi-trailer combinations. The objective of the paper is not to present data for general application but to show that extreme care should be exercised in selecting such values for any study involving highway planning, financial needs taxation, and engineering economy analyses.

(Continued on page 30)

SELECTED RECENT LITERATURE IN ENGINEERING JOURNALS

XIII. VEHICLE AND STREET LIGHTING

1. **Motor-Vehicle Industry, Significance of the Small Car**; *Engineering*, February 1954, pp. 234-237.
2. **Municipal Engineering in 1953, Public Lighting**; *The Surveyor, special annual issue*, February 27, 1954 pp. 27-28.
3. **The lighting of Streets and Highways, Advantages and Costs**; R. Pesson, *Strasse und Verkehr*, (*in French*)

   Part I-December 1953, pp. 453-457.

   Part II-January 1954, pp. 9-13.
4. **Maintenance of Street Lighting in Guildford**; E. R. Wye, *The Journal of the Institution of Municipal Engineers*, March 1954, pp. 409-417.
5. **Good Street Lighting-How to Have and Keep it**; E. B. Karns, *The American City*, March 1954, pp. 137, 139 & 143.
6. **Rear Lamps and Reflectors-New Legal Requirements at a Glance**; *Motor Transport*, April 16, 1954, p. 5.
7. **Wall-Mounted Lanterns Light Aberdeen Streets**; *The Surveyor*, April 24, 1954, p. 325.
8. **Street Lighting and Road Safety**; W. Robinson, *Contractors' Record and Municipal Engineering*, May 12, 1954, pp. 22-24.
9. **Horrow's Five-Year Street Lighting Programme**; *The Surveyor*, May 22, 1954, pp. 421-423.
10. **Seeing With Headlamps**; Val J. Roper. *Road International*, Spring, 1954, pp. 15, 18 & 62.
11. **New Lighting at Southampton**, *The Surveyor*, July 3, 1954, p. 568.
12. **Building-Front Fixtures Light City District**; *The Engineering News Record*, July 8, 1954, pp. 49, 51 & 52.
13. **Something New in Underpass Lighting**; H. G. Hrivnatz, *The American City*, August 1954, pp. 136 & 139.
14. **Traffic Island Illumination**; *Roads and Road Construction*, September, 1954, p. 272.
15. **Aberdeen's new Street Lighting**; *Roads and Road Construction*, September 1954, p. 284.
16. **Street Lighting and Road Safety-Need for Uniformity of Road Brightness**; *Highways and Bridges and Engineering Works*, September, 15, 1954, p. 10.
17. **Unusual Lighting in Milan's Via Caldara**; *Highways and Bridges and Engineering Works*, September 15, 1954, p. 14
18. **Street Lighting and Road Safety**; *The Surveyor*, September 18, 1954, pp, 795-796.
19. **Special place of Street Lighting in Road Safety Campaign-Need for a National Policy for Traific Route Lighting**; *The Surveyor*, September 18, 1954, pp. 797-798.
20. **Reflection on Light from Road Surfaces**; *The Surveyor*, September 18, 1954, pp. 798-800.
21. **The Road Surface as a Factor in Street Lighting**; Alexander William Christie, *Proceedings of Civil Engineers-Part II-Volume 3*, October 1954, No. 3, pp. 506-531.

22. **Kansas City, Missouri, Street Lighting Modernization Programme**; PAUL C. BOX, *Traffic Engineering*, September 1954, pp. 476-478 & 490-491.

23. **The Relighting of Maidenhead Bridge**; E. F. HANDRON. *The Journal of the Institution of Municipal Engineers*, November, 1954, pp. 249-256.

24. **The Association of Public Lighting Engineers**; *Roads and Road Construction*, October 1954, pp. 319-320.

25. **Street Lighting and Accidents**; *Roads and Road Construction*, October 1954, pp. 321-323.

26. **Road Goods Vehicles, Size and Unladen Weight-Overall Width of Loads**; *Roads and Road Construction*, October 1954, p. 316.

27. **The "Dazzle" Problem-Yellow Headlights not the Answer says D. S. I. R.**; *The Surveyor*, October 16, 1954, p. 890.

28. **Tunnel Illumination, Gaviota Gorge Project Develops New Ideas**; ROY MATTHEWS. *California Highways and Public Works*, November-December 1953, pp. 37 & 59.

29. **Street Lighting for Pedestrians and for Vehicles**; W. R. ELMER, *The American City*, October 1954, pp. 139-143.

30. **Single Light Poles have a Double Duty**; *Engineering News Record*, October 4, 1954, p. 45.

31. **Skidding and Braking Factor-Road Research Experts Give Their Views**; *Motor Transport*, November 12, 1954, p. 17.

See also **Skid resistance on rough and smooth road Surfaces**: *Surveyor*, November 13, 1954, pp. 985-986.

32. **Street Lamp Development-Mercury, Sodium Vapour and Fluorescent**; JOHN W. YOUNG, *American City*, December 1954, pp. 107, 109 & 111.

33. **A Bargain in Street Lighting**; *American City*, December 1954, p. 111.

34. **Haddington: Street Lighting**; F. P. TINDALL. *Journal of the Town Planning Institute*, *Volume XLI*, *No 2*, January 1955, p. 55.

35. **Tunnel Lighting a Comparison of the Methods Adopted in Various Countries**; *Contractors' Record and Municipal Engineering*, *Volume LXV*, *No. 52*, December 29, 1954, pp. 11-14.

36. **Accident Statistics and Road Surface Characteristics - Research in Two Aspects of Street Lighting**; A. J. HARIS AND A. W. CHRISTIE. *Contractors' Record and Public Works Engineer*, *Volume 6*, *No 4*, December 1954, pp, 28-37.

37. **Cut-Off Lighting at Coseby**; *Roads and Road Construction*, *Volume 33*, *No 385*, January 1955, p. 20.

EXPERIENCE IS A GREAT TEACHER

Experience is a great teacher, but by itself it may only deepen a rut. Experience coupled with study and research may produce revolutionary improvements. Without the search for new knowledge, for understanding of it, and for ways to use it, the lessons of experience would be learned to little profit.

Roy W. Crum

PUBLICATIONS ADDED TO THE ROADS WING LIBRARY DURING JANUARY, 1955

1. **Their Roads buy themselves** by Henry K. Evans (Chamber of Commerce of the United States, Washington 6, D. C).

2. **Industrial and other uses of rubberized bitumen** by A. R. Smee (British Rubber Development Board, Market Buildings, Mark Lane, London, E. C. 3).

3. **Bibliography on Soil Stabilization** (The Indian National Society of Soil Mechanics & Foundation Engineering, New Delhi). 2 copies

4. **Calculation, Design and testing of reinforced Concrete**, by K. L. Rao (Sir Issac Pitman & Sons, London, 1949).

Manager of Publications, Delhi.

5. **Census of India 1951, Vol. X-Rajasthan and Ajmer-Part I B - Subsidiary tables and district index of non-agricultural occupations**, by Pt. Yamuna Lal Dashora 2 copies

6. **Census of India, 1951 Vol. I - INDIA-Part II-B-Economic tables (General population)** by R. A. Gopalaswami 2 copies

M/s. McCalls Macalloy Ltd., Sheffield, England.

7. **Macalloy Prestressing steel for the lee-McCall system (3rd ed., 1953).**

8. **The Lee - McCall system in America-Bulletin No. I (Reprinted from Civil Engineering (U.S.A.), April, 1952).**

9. **The Lee-McCall system for the Lee Conservancy Catchment board - Bulletin No. 2. (Reprinted from an article in 'Concrete and Constructional Engineering,' Oct. 1954).**

10. **The Lee-McCall system for 160 ft span railway bridge-Bulletin No. 3 (Reprinted from "The Municipal Journal", 2-1-1953).**

(Continued from page 18)

be worthwhile in cases when a great number of identical members are involved.

Problems of stockpiling and of horizontal and vertical handling have to be solved. This calls for the special site equipment which has been for so long the prerogative of structural steelwork.

All this is expensive, and the risk of damaging the precast concrete members is always present, from a simple crack to the total loss of a member, often an important one.

Finally, and especially, in the case of ferro-concrete, the correct assembly of the various components is not always easy to carry out economically.*

(Extracted from "The Structural Engineer" November, 1954)

* Description of five works including a bridge is given in the article.

(Continued from page 26)

U. D. C. No. 624.21.09.4 RESEARCH ON HIGHWAY-BRIDGE FLOORS by N. M. Newmark and C. P. Siess. Proceedings of the Thirty-Third Annual Meeting of the Highway Research Board, Washington, D. C., 1954.

THIS Paper reviews the research on highway bridge floors carried out at the University of Illinois during the period from 1936 to 1954 under the sponsorship of the Illinois Division of Highways and the Bureau of Public Roads.

The object of this research has been to determine the behaviour of re-inforced concrete slabs subjected to vehicle wheel loads and to investigate the effects of the many variables encountered in different types of bridge-floor construction. The methods used have included a combination of mathematical analyses as well as extensive tests on scale-model bridges and on full size elements of bridges.

Two types of bridges have been studied: the simple-span solid-slab bridge with integral curbs and the I-beam bridge. Tests have been made on both right and skew bridges of both types, and on both simple-span and continuous I-beam bridges. Extensive analytical and experimental studies of composite action in I-beam bridges have also been made. In addition to these studies of actual bridge types, there have been several analytical and experimental investigations of fundamental problems involved in the behaviour of slabs subjected to concentrated loads.

The Paper includes brief descriptions of each phase of the investigation with references to the several publications in which the research methods and results have been reported in more detail. (Authors' Summary).

U. D. C. No. 691.3 INDIAN STANDARD FOR PORTLAND BLAST FURNANCE SLAG CEMENT. IS: 455-1953. Indian Standards Institution, 19, University Road, Delhi-8.

Portland Blast furance Slag Cement is obtained by mixing Portland cement clinker and granulated blast furnace slag in suitable proportions and grinding the mixture to get a thorough and intimate mixing of the two constituents. Its manufacture has been developed primarily to make a profitable use of an otherwise waste product, and to increase the total output of cement in the country.

The standard covers definitions of terms used in the trade and specifies standard methods of sampling chemical and physical requirements and methods of tests.

U. D. C. No. 620.1 THE INDIAN STANDARD SPECIFICATION FOR TEST SIEVES issued by the Indian Standards Institution, 19, University Road, Delhi-8, Price Rs 2.

This standard covers the following three series of sieves commonly used for testing purposes (a) Fine, made from wire cloth, (b) Coarse, made from wire cloth, and (c) Coarse, made of perforated plate (square holes). In respect of each series, the standard prescribes the requirements of sieving medium, namely wire cloth or perforated plate, frame, mounting, aperture widths, finish, marking, etc. The sizes of equivalent ASTM or BS Sieves are given. The method of examining Fine Test Sieves and the measurement of the aperture width and wire diameter of test sieves are included.

TOO MUCH TO HOPE FOR

Father: *"Now I want an explanation of this—and I want the truth."*

Son: *"Make up your mind, dad. You can't have both."*

UDGETS AND ADMINISTRATION REPORTS

Government of Bombay Budget for 1954-55

The following extracts have been taken from the Civil Works Budget estimates of the Government of Bombay for the year 1954-55.

	(Rs in lakhs)		
	Accounts 1952-53	Revised Estimate 1953-54	Budget Estimate 1954-55
Civil Works (Revenue)			
evenue			
(*a*) Rents	12.90	14.00	13.50
(*b*) Ferry Receipts	0.96	1.00	1.00
(*c*) Tolls on roads	0.01	0.01	—
(*d*) Receipts from self-supporting workshops	0.68	0.50	0.68
(*e*) Recoveries of Expenditure	1.73	1.50	1.50
(*f*) Miscellaneous	21.51	20.00	16.80
(*g*) Transfer from Central Road Development Account	33.12	100.00	218.53
Deduct-Refunds	-0.76	-0.22	-0.20
Total Revenue	70.15	136.79	251.81
Civil Works (Expenditure)			
A. Original Works			
(*a*) Buildings	42.55	47.12	104.59
(*b*) Communications			
(i) Ordinary	111.53	89.20	79.98
(ii) Central Road Fund	65.03	100.00	218.53
(*c*) Miscellaneous	0.65	0.04	0.02
Total Original Works	219.76	236.36	403.12
B. Repairs			
(*a*) Buildings	—	—	45.73
(*b*) Communications	83.95	84.52	42.49
C. Establishment	22.13	-34.84	-58.74
D. Tools and Plant	16.71	11.08	11.06
E. Grants-in-aid	18.54	16.83	18.38
F Suspense	—	-1.32	0.16
G. Charges in England	-1.55	-2.47	-0.06
Total Expenditure (A to G)	359.54	310.16	462.14

	(Rs In lakhs)		
	Accounts 1952–53	Revised Estimates 1953–54	Budget Estimates 1954–55
Capital Account of Civil Works outside the Revenue Account			
Original Works (Buildings)	78.17	86.02	192.69
,, (Communications)	20.31	15.80	19.51
Establishment Charges	17.54	18.33	33.95
Tools and Plant	1.46	1.53	4.24
Deduct-Receipt and Recoveries	–0.07	—	—
Total	117.41	121.68	250.39
Revenue from Roads			
Receipts under the Indian Motor Vehicles Act	38.34	24.00	14.78
Receipts under the State Motor Vehicles Taxation Act	154.85	225.00	225.00
Fees and other receipts	1.85	1.00	0.24
Deduct-Refunds	–4.42	–8.50	–2.70
Sales Tax on Motor Spirit	122.97*	175.00*	185.25*
Total I	313.59	416.50	422.57

*Gross receipts.

GOVERNMENT OF BOMBAY BUDGET FOR 1954-55.

(A brief review with reference to Civil Works).

TOTAL revenue receipts of the Government of Bombay for the year 1954-55 are estimated at Rs 7238.21 lakhs and revenue expenditure at Rs 7222.23 lakhs which indicate a surplus of Rs 15.98 lakhs. Revised estimates† for 1953-54 and Accounts† for 1952-53 show deficits of Rs 160.73 lakhs and Rs 602.77 lakhs respectively.

Revenue expenditure on Civil Works is estimated at Rs 462.14 lakhs as against Rs 310.16 lakhs in 1953-54 (Revised Estimates) and Rs 359.54 lakhs in 1952-53 (Accounts). This works out to about 6.4% of the State revenue for 1954-55, 4.5% for 1953-54 (Revised Estimates) and 5.8% for 1952-53 (Accounts).

Expenditure on communications alone (Original Works and Repairs only) is estimated at Rs 341.00 lakhs for 1954-55 which forms 4.7% of the estimated total revenue (Separate figures under Repairs for communications are not available for 1953-54 and 1952-53). The increased provision for communications under Original Works is because of the larger transfer from the Central Road Fund to finance the works already in progress as well as new works to be taken up under the Central Road Fund programme.

Capital expenditure on Civil Works outside the revenue account is estimated at Rs 250.39 lakhs for 1954-55 as against Rs 121.68 lakhs for 1953-54 (Revised Estimates) and Rs 117.41 lakhs for 1952-53 (Accounts). Major part of the capital expenditure is accounted for by buildings.

† After excluding the contribution of the Central Government on account of National Highways as well as the expenditure incurred under that head.

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

S. No.	Job No.	Name of work	Amount (Rs in Lakhs)
		ASSAM	
1.	1044 AS 39	Providing stone paved drains within the slip area between miles 69 to 78 of D. I. Road-N. H. No. 39 in Imphal sub-division.	0.15
2.	1048 AS 40	Widening Gauhati-Shillong Road (N. H. No. 40) between Jorahat and Burnihat to make it two way.	2.46
3.	1055 AS 39	Construction of Diversion Road between Barpathar and Dimapur (from M. P. 35 to Dimapur) N. H. No. 39.	10.19
		MADHYA PRADESH	
4.	1045 CP 7	Reconstructing and surfacing miles 3-57 of Jabalpur-Merzapur Section of N. H. No. 7.	9.44
		HYDERABAD	
5.	1047 HD 7	Constructing approach road to Panganga bridge on Hyderabad side in mile 195 of Hyderabad-Nagpur Road-N. H. No. 7.	0.94
		BOMBAY	
6.	1049 BM 8	Construction of cross drainage works on the Himmatnagar Gamdi sub-section of the Himmatnagar Raigadh Section of Bombay-Ahmedabad Road, N. H. No. 8.	0.76
7.	1065 BM 8	Providing black-topping with 3/4" asphalt carpet on the Prantij-Himmatnagar Section of the Bombay-Ahmedabad-Delhi Road, N. H. No. 8.	2.36
8.	1070 BM 8	Construction of a diversion of National Highway No. 3 near Nasik City.	3.45
9.	1085 BM 50	Black topping miles 5/4 to 125/0 of the Poona-Nasik Road, N. H. No. 50 in Poona and Nasik Districts.	26.91
10.	1095 BM 8	Construction of 3 R. C. C. minor bridges on Hariala-Kanera-Bareja Section of Bombay Ahmedabad Road, N. H. No. 8	0.94
11.	1096 BM 8	Construction of a R. C. T. Beam Bridge across Golalej Channel in mile No. 5/0-330′ on N. H. No. 8.	0.68

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS—(*Continued*)

S. No.	Job No.	Name of work	Amount (Rs in Lakhs)
12.	1097 BM 8	Construction of a R. C. T. Beam Bridges across Khasi river in mile No. 6/4-50' of N. H. No. 8.	0.65
13.	1103 BM 6	Black-topping 12 feet width of the Surat-Dhulia-Edlabad-Nagpur Road, N. H. No. 6 from mile 140/0 to mile 148/6.	0.92
14.	1104 BM 6	Black-topping 12 feet width of the Surat-Dhulia-Edlabad-Nagpur Road, N. H. No. 6 from mile 148/6 to 191/0.	8.60
		HIMACHAL PRADESH	
15.	1050 HP 22	Widening 6 ft track to full width, H. T. road N. H. No. 22 - from Rampur to Gaura (1st five miles)	7.48
16.	1054 HP 22	Widening of 6 ft track to full width from Luri to Rampur 1st five miles portion of Hindustan Tibet Road - N. H. No. 22.	7.58
17.	1063 HP 22	Widening 6 ft track to full width of the first five miles of Gaura-Wangtoo Section of H. T. Road, N. H. No. 22.	7.98
18.	1074 HP 22	Widening 6 ft track to full width of 2nd five miles of Rampur-Gaura Section of Hindustan Tibet Road, N. H. No. 22.	6.94
19.	1075 HP 22	Widening 6 ft. track to full width of the last five miles of Gaura-Wangtoo Section of Hindustan Tibet Road, N. H. No. 22.	7.93
20.	1077 HP 22	Widening of 6 ft. track to full width of 24 ft from Narkanda to Luri (40/0 to 45/0 miles) portion of Hindustan Tibet Road N. H. No. 22	5.74
21.	1084 HP 22	Widening 6 ft track to full width of Hindustan Tibet Road from Wangtoo to Chini (1st five miles)	8.64
22.	1091 HP 22	Construction of an explosive Magazine at Paunda on Hindustan-Tibet Road, N. H. No. 22	0.06
23.	1109 HP 22	Construction of 8-ton magazine for the storage of explosives at Dhalli on Hindustan Tibet Road.	0.12
		WEST BENGAL	
24.	1051 BG 34	Black topping Dhullian - Raghunathganj Section of N. H. No. 34 (Phase II works).	2.07

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS—(*Continued*)

S. No.	Job No.	Name of work	Amount (Rs in Lakhs)
25.	1053 BG 31	Reconstruction of 3 culverts on the Bagrakote-Dalgaon Section of N. H. No. 31 damages by the floods of 1950.	0.77
26.	1059 BG 35	Widening the metalled crust of N. H. No. 35 from Dum Dum to Barasah from 12 ft to 22 ft.	7.14
27.	1066 BG 31	Reconstruction of Chel bridge on N. H. No. 31.	12.64
28.	1067 BG 31	Reconstruction of Mal bridge on N. H. No. 31.	7·52
29.	1068 BG 31	Reconstruction of Neora bridge on N. H. No. 31	12.89
30.	1076 BG 35	Widening the metalled crust on N. H. No. 35 from Gaighata to Bangaon from 8 to 12 ft.	7.12
		DELHI	
31.	1052 DLHI	Improving G. T. Karnal Road from mile 9/0 to 11/0 and 14/0 to 15-2½ furlong.	1.45
32.	1060 DLHI	Improvements to Lower Bela Road from Rajghat to Jamna Bridge Part I—Diversion of existing Nala, widening one culvert and improvements to an existing drain running along the city wall.	1.97
33.	1061 DLHI	Improvements to Lower Bela Road from Rajghat to Jamna Bridge - Part II.	2.73
34.	1062 DLHI	Improvements to Lower Bela Road from Rajghat to Jamna Bridge-Part III-constructing a traffic island near Rajghat.	0.43
		ORISSA	
35.	1056 RS 6	Re-alignment of the curve at mile 143 of Raipur-Sambalpur Road - N. H. No. 6 (Land acquisition).	0.02
		PUNJAB	
36.	1057 PB 1	Raising the road in mile 196/2 to 196/7 of G. T. Road (N. H. No. 1) in Ludhiana Distt.	0.86
37.	1079 PB 2	Construction of a bye-pass at Palwal Town on Delhi-Mathura Road (N. H. No. 2) in Gurgaon District.	2.51
38.	1080 PB 2	Construction of a bye-pass at Hodal Town on Delhi-Mathura Road (N. H. No. 2) in Gurgaon District.	2.74

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS—*(Continued)*

S. No.	Job No.	Name of work	Amount (Rs in Lakhs)
		MADHYA BHARAT	
39.	1069 MB 3	Widening the existing 10 ft. of blacktop surface to 12 ft. in miles 50 to 56 and 58 to 59 of N. H. No. 3 in Gwalior Division No. II.	0.96
40.	1078 MB 3	Providing electric and water supply fittings in dak bungalow at Morena in Gwalior Division on N. H. No. 3.	0.30
		RAJASTHAN	
41.	1071 RJ 8	Widening the road formation and providing stone pitching on Alwar-Jaipur road, N. H. No. 8.	1.81
42.	1072 RJ 8	Widening and tarring Alwar-Jaipur road near Thana Ghazi bus stand.	0.04
43.	1073 RJ 8	Providing shoulders with dry stone pitching on Alwar-Jaipur road, N. H No. 8 from Alwar City to Jaipur Distt. border.	1.21
44.	1089 RJ 8	Improvement of miles 44-54 of Kankroli-Dewair road, N. H. No. 8 in Rajasthan.	2.46
45.	1092 RJ 8	Renewal and widening of road from 10 ft to 12 ft and black topping miles 30-18 of Udaipur-Nathdwara road.	2.95
46.	1098 RJ 8	Metalling and painting (including improvement of grades and curves etc.) of Udaipur-Kherwara road, N. H. No. 8.	0.50
		SIKKIM	
47.	1082 SK 31A	Providing seal coat over premixed carpet work between miles 0/0 to 25/0 of Rangpo-Gangtok Cart Road, N. H. No. 31-A.	1.76
48.	1083 SK 31A	Providing seal coat over premixed carpet work between miles 25/0 to 38/4½ of Teesta, Rangpo Road, N. H. No. 31-A.	1.02

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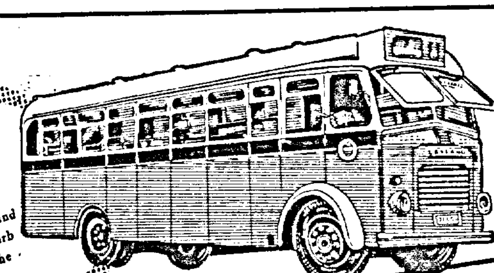

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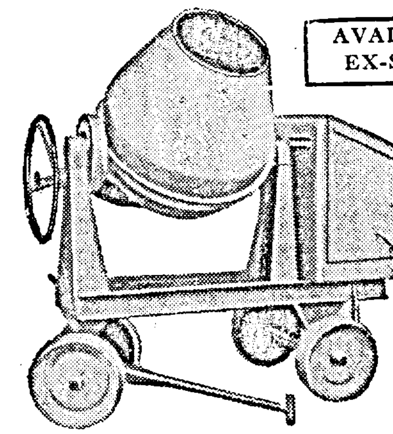

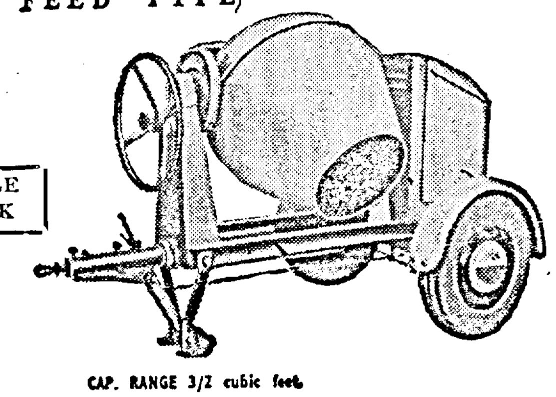

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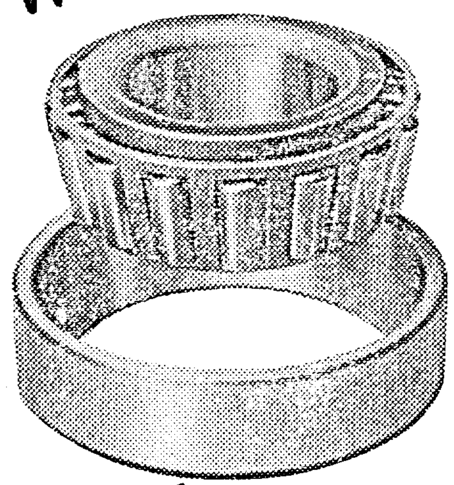

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