3. Correction due to depth = 0

∴ Total value of ϕ = 57.25 − 4.3 + 4.62 + 2.60

= 60.17

Limitation of the Method

The above described method for calculating the uplift and exit gradient is admissible under the following limitations:—

(*i*) The flow is two-dimensional.

(*ii*) The sub-stratum is homogeneous, isotropic and deep. This implies a reasonable homogeneity of particle size, its packing and resulting pore space.

(*iii*) There is no silt blanket or semi impervious layer upstream or downstream of the impervious floor.

(*iv*) There is no temperature gradient in the direction of or against flow.

Correction may therefore be applied if silt or scour condition exists in nature. Similarly temperature effects may be included by calculation to arrive at correct value of ϕ (uplift pressure). Though there is to be not much variation in temperature, however the first two conditions are such which warrant special discussion.

1. **Three Dimensional Flow and Bridge abutments etc.**

The assumption that the sub soil flow is two dimensional hold only in cases of major portion of a long weir on rivers or dams etc. where flow from flanks do not interfere with the flow along the axis of the work. But in case of foundation for flanks and bridge abutments and small canal falls in highly waterlogged areas the condition of two dimensional flow may not hold. The spring level in the adjacent banks or saturated fills may be higher than the foundation level and floor level of the work. So in addition to flow under the work there may be flow from sides. Thus creating conditions of three dimensional flow, which may affect the entire velocity vector (of the under seepage). The exact theoretical approach to the design of floors etc. for three dimensional flow is yet to be investigated. As a general guide to the safety of structures, however, Mr. Haigh and Khosla recommended that besides sheet piles on upstream and downstream sides, the foundation of abutment and flanks should go down to the bottom of these pile lines. With such an arrangement it may be possible to obtain the conditions that uplift pressures under the work due to flank flow may not be more than those due to direct flow under the work.

2. **Variations in Permeability — Non-Homogeneity of Soil**

Homogeneity of sub soil formation is one of the essential condition under which the above analysis of pressure distribution is applicable. In actual practice, however, it is rather impossible to find conditions approximating to homogeneity and wide range of variation may occur. So a stream line travelling from a medium of one permeability will get deflected when made to pass through the medium of a different permeability. Therefore the said lines before emerging out again may have to pass through various strata of different permeabilities thus changing the overall pattern.

Mr. Karl Terzaghi in his paper "Effects of minor geological details on the safety of dams" (American Institute of Mining and Metal Engineers Inc. 1929) remarks, "The failure of weirs resting on stratified materials occurred several years after the water was stored up, whereas according to the theory for uniform materials and according to the laboratory

evidence obtained from uniform material, failure occurred either or not at all".

Some work has been done in Irrigation Research Institute to find out how non-homogeneity of sub stratum affects the uplift pressures. Given below are extracts from Paper 294 presented to Punjab Engineering Congress:—

The Non-Homogeneity of the Substratum

It is not possible to deal with all the variations in the substratum which can possibly occur; a few simple and common cases of non-homogeneity are, however, dealt with qualitatively. The exact uplift pressures for such cases can only be determined from hydraulic models, but the general trend of change of uplift pressures from the normal gradient for typical cases of non-homogeneity can help in the proper understanding of departures in observed hydraulic gradients from theoretical ones. The non-homogeneity can be broadly divided into three main types:—

(*i*) Discontinuity of media across the lines of flow under the weir *i.e.*, vertical or oblique stratification of geological faults etc.

(*ii*) Discontinuity occurring parallel to the direction of flow under the weir, or horizontal stratification etc.

(*iii*) Conglomerations of sand and clay, or sand and shingle.

I. Vertical or Oblique Stratification

Material considerably coarser or finer than the average subgrade occurring across the path of percolation below the weir, would cause a change in the flow pattern and pressure distribution. Evidently, a layer of coarser grade or of shingle in contact with the underface of a weir will offer an easy path to flow lines, and the lines of flow would be drawn on to it. If such a layer exists under part of the length of the weir, the effective length of the weir will be decreased. Hydraulic gradients if compared with those for homogeneous foundations the main indication is that the gradient through the medium of greater permeability is flatter than the normal gradient, and upstream of it the gradient becomes steeper.

If, however, the medium obstructing lines of flow is considerably finer than the general subgrade, or consists of an oblique or vartical clay layer, the pressure on the floor would increase or decrease according as the oblique or vertical clay layer is near the downstream or upstream end of the floor; an oblique or vertical clay layer near the downstream end will act analogously to a downstream sheet pile, and will pile up pressure on the floor; while a clay layer near the upstream end will tend to reduce pressure on the floor.

II. Horizontal Stratification

(*i*) Works resting on and underlaid by shingle or coarser material.

Evidence so far available shows that if the medium changes in depth from less to greater permeability (or is horizontally stratified), the difference in the hydraulic gradient from that of a work resting on a homogeneous bed, is not as great as in a case of vertical stratification. Experiments carried out in connection with Marala Weir, which was known to be built on a 25 feet thick layer of sand foundation underlaid by shingle, gave the flow lines and hydraulic gradient which bears out the above conclusion.

(*ii*) Works resting on sand underlaid by an impermeable clay stratum of finite depth.

To this type belongs the Sulemanki weir and Bay 4 of Khanki, weir. If a sheet pile is imbedded into a clay stratum or pierces, it cutting off the upstream portion from the downstream, the sheet pile will cutoff all the head, and no pressure will be transmitted to the downstream floor. The pressure line downstream of the floor will follow the downstream water level and will be completely independent of the upstream level.

(*iii*) Works resting on sand underlaid by an impermeable clay stratum of infinite depth.

For a pileless floor resting on sand of finite depth, the uplift pressures have been fou nd to be less under the downstream half and more under the upstream half, than in the case where the sand is infinitely deep, though the difference is not appreciable, unless the floor is at least four times as long as the depth of sand. When the sand depth is very small, the fall of pressure tends to be very nearly proportional to distance except for a certain rapid loss at entry and exit. This incidentally explains the linear relationship of Clibborn which later appeared as the creep hypothesis.

For a floor with a pile driven into the clay stratum, the effect would be similar to case (ii) above.

III. Conglomeoration of Subgrade

Works on a mixture of sand and clay or sand and shingle, more or less uniformly distributed.

No experimental data exist for the case of works resting on sand and clay to show the trend of variation from the normal uplift pressures. A few experiments carried out on a model of Kalabagh wier on a foundation of sand and shingle mixed in different ratios, show that the uplift, pressures, are generally higher when a weir rests on a mixture of sand and shingle, than those for homogeneous sand foundations.

New Rasul Barrage — Trouble after Construction

New Rasul Barrage constructed across River Jhelum 2½ mills downstream of old weir forms part of Indus Rasin replacement plan. The barrage completed in December, 1967 was commissioned in January, 1968. It has 48 bays of 60 feet span each. Out of these 6 bays on left form undersluices (depressed floor) and the others represent standard section or the main weir. Rasul Qadirabad Link, discharge 19,000 cusecs and L.J.C. feeder with a capacity of 3,000 cusecs offtake on the left. In order to keep a check on its safety against uplift etc. pressure pipes have been installed at various places (as shown in the drawing) and such peizometeric observations are being made along piers 1, 8, 16, 27 and 38.

Geological Formation

In general the foundation is made up of river-lain pervious material — sands, gravels and silty sands. However, the bore holes at the left hand side of the Barrage encountered a tough, plastic and impermeable clay layer between approximately elevation 670 to 675. Examination of the bore legs and sections shows that this is a massive clay layer which extends for considerable distance downstream and that it becomes thicker in the downstream direction. The clay also appears to extend for a considerable distance left of the left abutment. The upstream edge of the clay moves downstream from left to right, so that it is clear of the downstream floor at approximately pier 6. The clay was encountered in

the excavation for the undersluice bays (Bays 1 through 6), and was removed from beneath the downstream floor of these bays during construction.

Escape of Bubble Near D/S Apron and Pressure Point Readings

During early February when the head across the barrage was about 16 feet, observation of silt circles and bubbles of air confining mainly to the downstream apron were reported in the still water there. The silt circles were described as patches of 4 feet to 9 feet diameter. This phenomenon was again observed between March 25 to April 8 when the head across was between 18' — 20' and the still water conditions prevailed downstream. Skin divers sent down to investigate the craters in the silt cover from where bubble seemed to originate reported that some of the craters were an arm's length deep and were warmer than the surrounding water.

Pressure point readings right from early February began to show that the pressures under the downstream floor at pier 1, 8, and 16 were definitely higher than computed pressures by Khosla's theory. The highest observed piezometer levels were at pier 1. The preliminary computation however, indicated the head across the barrage could be increased to 20 feet without endangering the stability of the downstream floor. In a meeting later it was decided that the head across should be restricted to maximum upstream pond level of R.L. 715.

During the period 27 February to 7 March all the pressure pipes were cleaned and purged with water under compressed air but the observed pressure under downstream floor of pior 8 continued to be higher than other standard bays but not as high as pier 1.

In view of the operating restrictions and possible danger to the barrage Government of Pakistan has appointed a pannel of eminent Pakistani Engineers to probe into the causes of excessive uplift pressure and to suggest remedial measures etc. In the meantime 24 relief wells in the downstream block apron of undersluices have been installed. They are at 15 feet spacing located in the 5th row of blocks of the undersluice downstream block apron. The matter is now being examined by the pannel and I think it may not be advisible to express any opinion at this stage.

Other Structures Subjected to Uplift Pressures etc.

Other examples of structures that are subjected to the uplift forces under certain conditions are reinforced concrete settling basinsin water filteration plants, lowest basement floor slabs in structures which are set deep under the ground well below natural water table, dry-docks, quay walls, bridge piers etc.

The settling basin is generally built on pile foundation and it is common practice to build such structures below the ground surface and to cover them with a few feet of earth fill. The base of the structure is well below natural ground water table. When the basin is full of water the net weight (downward) weight of the structure (—) the uplift due to hydrostratic pressure) is downward. But when such a structure is emptied for cleaning or for other reasons it is often so light that it tends to lift off its foundations because of the hydrostratic head. In such a case it is necessary to make sure that the piles are properly connected to the structure so that the joints can resist tension. It is also necessary that the piles are properly fastened in the soil. In addition the bottom slab of the structure must be designed for upward hydrsstratic pressure.

A similar situation as above may often arise in deep basement floors and in other structures which are set deep in ground well below the natural ground water table. The floors must be designed to resist the uplift. Where drainage and pressure release arrangements have been made it is very necessary to see that while the pressure is released below the undation or basement floors there is no escapage of fines from underneath the foundation.

Bridge pier which is also subjected to hydraulic uplift or bouyant forces of water around and under the pier, its stability should be tested against the forces acting upon it with respect to sliding downstream, sliding in the direction of the axis of the bridge, over turning about the downstream toe and over turning about the one side of the footing.

The condition in dry-docks become similar as in concrete settling basin described above for deep basement floors when the water is pumped out of the enclosure, for repair to the ships etc. Arrangements therefore should be made for uplift and loss of fines below the floors and side walls etc.

Acknowledgements

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Culvert With No Afflux*

By GORDON R. MCKAY

A cheap hydraulic design of culverts have been developed at the University of Queensland on the principle of minimum constant energy of flow to attain maximum discharge. Culverts rectangular in section were taken into consideration.

If bed level of culvert is same as that of approach channel discharge per foot run through culvert is worked out from critical depth formula

$$q_{max} = Y_e \sqrt{gY_c}$$

$Y_c = \frac{2}{3} \times$ *depth of flow in the approach channel. Approach channel of any width can be converged to a suitable convergence angle to the culvert of width* $\frac{Q_{max}}{q_{max}}$

If it is desired to set the bed level of culvert at a level lower than the bed of approach channel then width of culvert is arbitrarily chosen and q_{max} *is worked out from* Q_{max} *of culvert. Knowing* q_{max} *critical depth* Y_c *is worked out from the above formula and bed level of culvert = H.F.L. + velocity head* $-3/2\ Y_c$.

Again vertical bed transition is fixed arbitrarily and width is worked out at each point of transition by dividing Q_{max} by q_{max} *where* q_{max} *is maximum per foot width discharge at the particular point which in turn is worked out from above critical depth formula assuming critical depth equal to two-third of difference of energy level and bed R.L.*

This design for culverts is perhaps the most important of many applications of new techniques which has been developed at the University of Queensland over a number of years. The actual construction involves a number of features which have to be used if the full cost saving available is to be fully exploited.

The Hydraulic Design

The hydraulic design is based primarily on the condition that there must be constant

*The Institute of Engineers, Australia Symposium 1968.

energy of flow. At the design flow obviously the cheapest structure will be attained when this energy is a minimum because it is in this condition at which maximum discharge occurs for a particular energy.

In general, therefore, it follows that everywhere

$$A \frac{\sqrt{A}}{\sqrt{B}} = \frac{Q}{\sqrt{g}}$$

when A = area of flow
B = surface width
g = gravitational constant
Q = discharge.

The only data required for design purposes are—

(1) the water level at design flow
(2) the ground level
(3) the design flow or alternatively the average velocity of approach.

If anything is known, the flood level is usually available or can be assessed. The ground level can be measured. A reasonable estimate of velocity suffices. Oddly enough, although the design procedure gives a unique solution in every case, normal margins of safety can deal with significant errors in assumed velocity.

For rapidity and ease of explanation, I am going to deal with rectangular shapes perpendicular to the flow. In this case B = constant at a section and if the depth is y, A = By.

Thus $A \sqrt{\frac{A}{B}} = \frac{Q}{\sqrt{g}}$

becomes $B\, y_c \sqrt{\frac{B\, y_c}{B}} = \frac{Q}{\sqrt{g}}$

y_c being the critical depth,

thus $y_c = \sqrt[3]{\frac{q^2}{g}}$

when q is flow per ft and $\frac{Q}{B}$

also as $y_c = \sqrt{g\, y_c}$

$y_c = 2/3\ H_s$ the specific energy

and $\frac{v^2_c}{2_g} = \frac{y_c}{2}$

thus $q_{max} = y_c \sqrt{g\, y_c}$

Assume a flow 3 ft. deep approaching a proposed road embankment at 2 ft./sec. Assume ground level as R.L. 100.

The total specific energy of the approach flow is $3 + \frac{4}{64}$.

The velocity energy is so small that it can be neglected as a safety margin.

Thus the R.L. of the energy line is 103 and this must be constant.

Assume that you require to pass a 100 ft. width of flow through a 10 ft. wide culvert. This choice is quite arbitrary, equally the flow width can be 50 ft. or 120 ft. or the culvert width altered. The approach discharge is 6 cusecs/ft. (3 ft at 2 ft./sec). Thus the total flow in a 100 ft. width is 600 cusecs.

The critical depth with a specific energy of 3 ft. is $y_c = 2/3\ H_s = 2/3 \times 3 = 2$ ft. Therefore the maximum discharge is

$$y_c \sqrt{g y_c} = 2 \sqrt{32 \times 2} = 16 \text{ cusecs/ft.}$$

Thus the 100 ft width can be converged without any change of ground level to

$$\frac{600}{16.0} = 37.5 \text{ ft.}$$

Any further convergence must be accompanied by a fall in ground (bed) level.

At the culvert

$$q = \frac{600}{10} = 60 \text{ cusecs/ft.}$$

$$\text{Thus } y_c = \sqrt[3]{\frac{60^2}{32}} = 4.83 \text{ ft.}$$

$$\text{Thus } H_{s_{min}} = 4.83 + 2.42 = 7.25 \text{ ft.}$$

As the specific energy line is at R.L. 103, the culvert invert is set 4.25 ft. below ground.

The water level through the culvert is at 100.58.

It remains to bring 37.5 ft at R.L. 100 to the 10 ft wide culvert invert at R.L. 95.75. Once again there is complete arbitrary choice of width or depth, but not both. Assume we use a uniform grade of 1 in 8. The length of the transition is $8 \times 4.25 = 35$ ft, 37.5 ft. wide at the top and 10 ft wide at the bottom.

Halfway up the transition the bed level is R.L. 97.87. The energy is therefore 5.13 ft., thus

$$y_c = 3.42 \text{ ft.}$$

$$q_{max} = 3.42 \times \sqrt{3.42 \times 32} = 35.8 \text{ cusecs/ft.}$$

thus width is $\frac{600}{35.8} = 16.75$ ft.

At the lower quarter point width is 12.7.

At the upper quarter point width is 23.9.

Provided these widths are measured at the quarter points, they would in fact be the same whatever uniform grade is used.

Equally a convergence with straight sides could be used and the depth of the bed calculated, but it would be curved.

Or alternatively, a particular curve can be chosen for the sides and again the depth of the bed calculated for this curved wall.

It should be noticed also that the widths calculated are, in due regard to the requirements of fluid mechanics, at right angles to the flow. We have found it convenient to consider them as circular arcs.

If the sides are battered, this requirement must also be considered in the vertical direction.

It should be noticed that the water level through the culvert is at R.L. 100.58, *i.e.*, 2.42 ft. below the approaching flow. Assume the road is set at flood level and the slab is 1 ft thick. Before the culvert will flood, the water can rise to R.L. 102.

In these conditions $y_c = 6.25$ and $q = 88.4$ cusecs/ft (which is over 47% in excess of the design flow) max and the approach flow will rise 2.12 ft.

The flow is returned to the 3ft depth and 2ft/sec by an exit of similar design.

If non-rectangular sections are used, it is convenient to compute the widths for a given depth and given batters.

The design procedure is applicable to round pipes, but it the pipes are used more than half full, a 'special' will be necessary at exit and entry.

The design will be advantageous in many circumstances as if invariably requires the invert to be set down. Thus it is rarely necessary to lift the whole road to obtain cover over the culverts.

The velocity through the culvert is always considerably higher than the approach flow. Sediment is therefore unlikely to collect in the culvert. Anything that can be carried into the culvert will be carried out.

(Continued on page 67)

Crushing Strength of Concrete made from Locally Expanded Clay Aggregates

By

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The lightweight aggregate concrete has gained considerable popularity in the developed countries during the last two decades and by now it is a firmly established building material in USA, USSR and some European countries. But the lightweight aggregate concrete has not been used in Pakistan although high cost of natural stone aggregate in some regions and increasing trend in construction of high buildings are forcing us to look for cheaper and lighter aggregates. The lightweight aggregates owe their popularity principally to the fact that they produce concrete lighter than that of gravel whereby the self weight of structures are reduced by about 20% which is a distinct advantage for prefabrication. The thermal conductivity of expanded clay aggregate concrete is about 1/6th that of gravel concrete which property is useful both in the cold climate where the problem is to retain the internal heat as well as in tropics where the external heat flow into the building has to be reduced.

INTRODUCTION

"Lightweight Aggregate Concrete" is the term applied to the concrete in which stone aggregates are replaced by lightweight aggregates which are either porous, hollow or cellular in structure. There are three categories of light-weight aggregates *viz.*, (*i*) natural aggregates, (*ii*) by-products of industry, (*iii*) processed aggregates. The natural lightweight aggregates include Pumice, Scoria (Volcanic Cinder) etc. The aggregates from by-products of industry are cinders, air cooled slag, coke etc. The processed (or manufactured) aggregates include Clinker, Expanded Clay, Expanded Shale, Expanded Slate, Exfoliated Virmiculite, Expanded perlite, Foamed Slag etc. The processed lightweight aggregates depend mainly upon availability of the raw materials in the locality.

Lightweight aggregate concrete is in no way a new building material but it has been in use during the late 19th century in America and England in the form of Clinker concrete.

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Natural stone aggregates (popularly known as bajri) are transported from long distances from Northern Hills in West Pakistan for the Central Districts of Lahore, Sahiwal, Multan, Bahawalpur and Rahimyarkhan. The cost of aggregates is therefore rather high, varying from Rs. 130 to Rs. 175 per cent cft, with the result that concrete construction in the above major towns is rather expensive. In an effort to reduce cost of construction, the Building Research Station Lahore envisaged a scheme for investigating possibilities of bloating West Pakistani alluvial soils in 1965. The scheme was approved by U.K. Government under Colombo Plan and one of their experts Mr. William Kinniburgh of Building Research Station, London was deputed for a couple of months to carry out investigations with the help of equipment which was also donated by the U.K. Government. Many soil samples collected from various sites tested for their bloating characteristics and a detailed report is given in "Technical Feasibility of producing lightweight aggregates from clays of West Pakistan" (Building Research Station, London Report No. IC 2/69).

The popularity of expanded clay aggregates in Pakistan will depend on the strength properties of concrete for which the present investigations were taken in hand to compare with conventional 1: 2: 4 concrete made from natural gravel aggregates.

Successful results on expansion of local clays encouraged the setting up a Pilot Plant for actual production of the expanded clay aggregate so as to have sufficient quantity for concrete testing. A Pilot Plant with a small gas fired rotary kiln capable of making about 3/4 tons of expanded clay aggregates in a day, was installed by Packages Ltd., Lahore in March 1969 under the auspices of Building Research Station, Lahore. Full description of Pilot Plant is given in a separate report. The expanded clay aggregates used in this report were manufactured from clay obtained from a brick kiln on Ferozerpur Road, Lahore to which Packages effluent (after the manufacture of cardboard) containing about 0.2% organic materials was used as mixing water for making of pallets. The kiln was heated to 1150°C—1250°C by natural 'Sui' gas for the manufacture of expanded clay aggregates.

PHYSICAL PROPERTIES OF AGGREGATES

The physical properties of aggregates *i.e.*, bulk density, specific gravity and water absorption were determined according to relevant British Standard and are shown in Table 1. It will be seen that the bulk density of expanded clay aggregates is about 56 lbs/cft. which falls within 60 lbs/cft. limit specified in B. S. 3797 : 1964. The water absorption of oven-dried, expanded clay

TABLE 1

Properties of the Aggregates.

Type of aggregate	Physical Properties		
	Bulk Density lbs/cft.	Specific Gravity	Water absorption % at 24 hr.
1. Locally expanded Clay Lightweight Aggregate.	56	1.7	7.1
2. Bajri (Usman Khattar)	88	2.69	0.93
3. Ravi Sand	89	2.60	1.91
4. Lawrencepur Sand	102	2.67	2.86

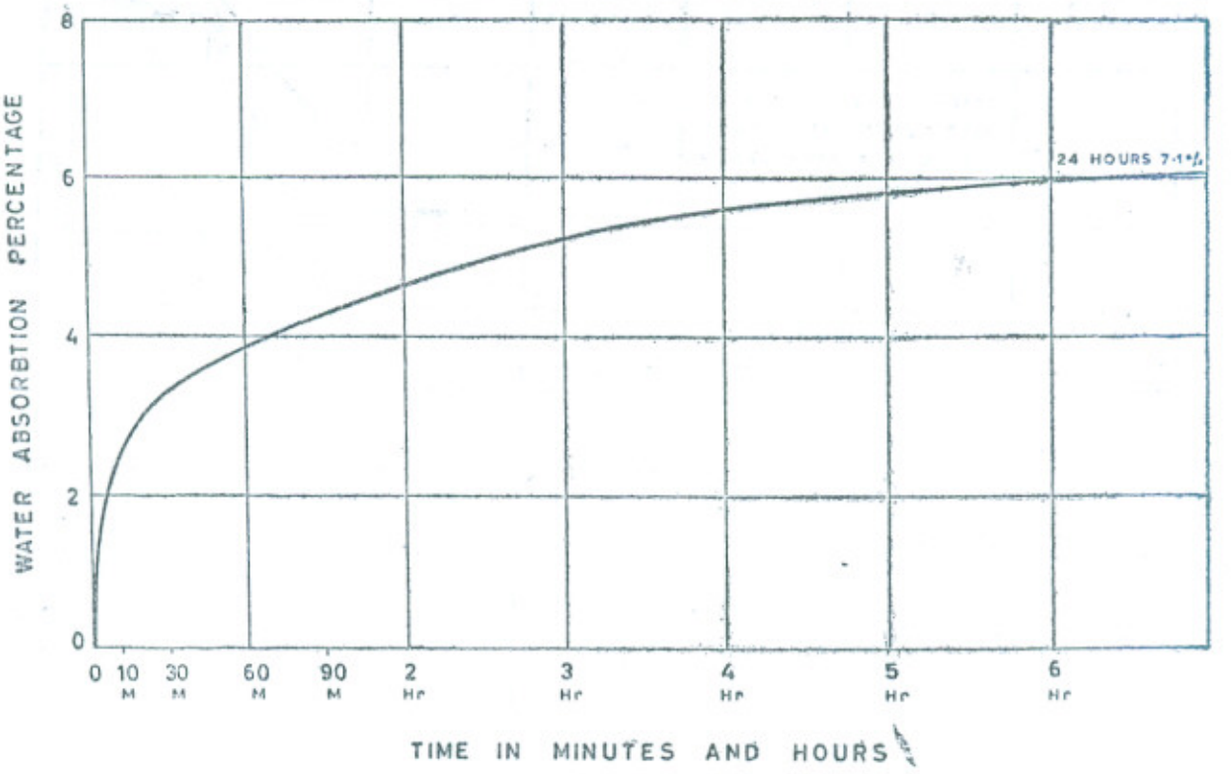


FIG. NO. 1 RATE OF WATER ABSORBTION OF ½" GRADED LOCALLY EXPANDED CLAY AGGREGATE

aggregate at intervals of 10 minutes, 30 minutes, 60 minutes, 1½, 2, 3, 4, 5, 6 & 24 hours was determined and is shown in Fig. 1. It will be seen that the expanded clay aggregates absorb about 75% of water within the first hour or so of their immersion in water.

FINE AGGREGATE

Two types of fine aggregates namely Ravi sand and Lawrencepur sand have been used separately in the trial mixes. Ravi sand is locally available from bed of river Ravi passing through Lahore and is commonly used in concrete work. Lawrencepur sand is coarser and is quarried from Lawrencepur about 200 miles away from Lahore and is therefore about 4 times more costly than Ravi sand. The sieve analysis of each of the aggregates and the combined grading of coarse and fine aggregates after converting to weight basis is given in Table 2. It will be seen that Ravi sand is much finer than the grading specified in Zone 4 while Lawrencepur sand conforms to the limits specified in Zone 2 of B.S. 882 : 1965. The combined grading with Ravi sand does not fall within any of the zones mentioned in Research Report No. 2, June 1955 although the mix with Lawrencepur sand may be taken to fall within Zones 1 to 4 as seen in Fig. 2.

PREPARATION OF AGGREGATES FOR CONCRETE

The expanded pallets aggregates received from the Pilot Plant were more or less of a uniform size of 1½". These were crushed down to 1/2" by the Laboratory crusher and

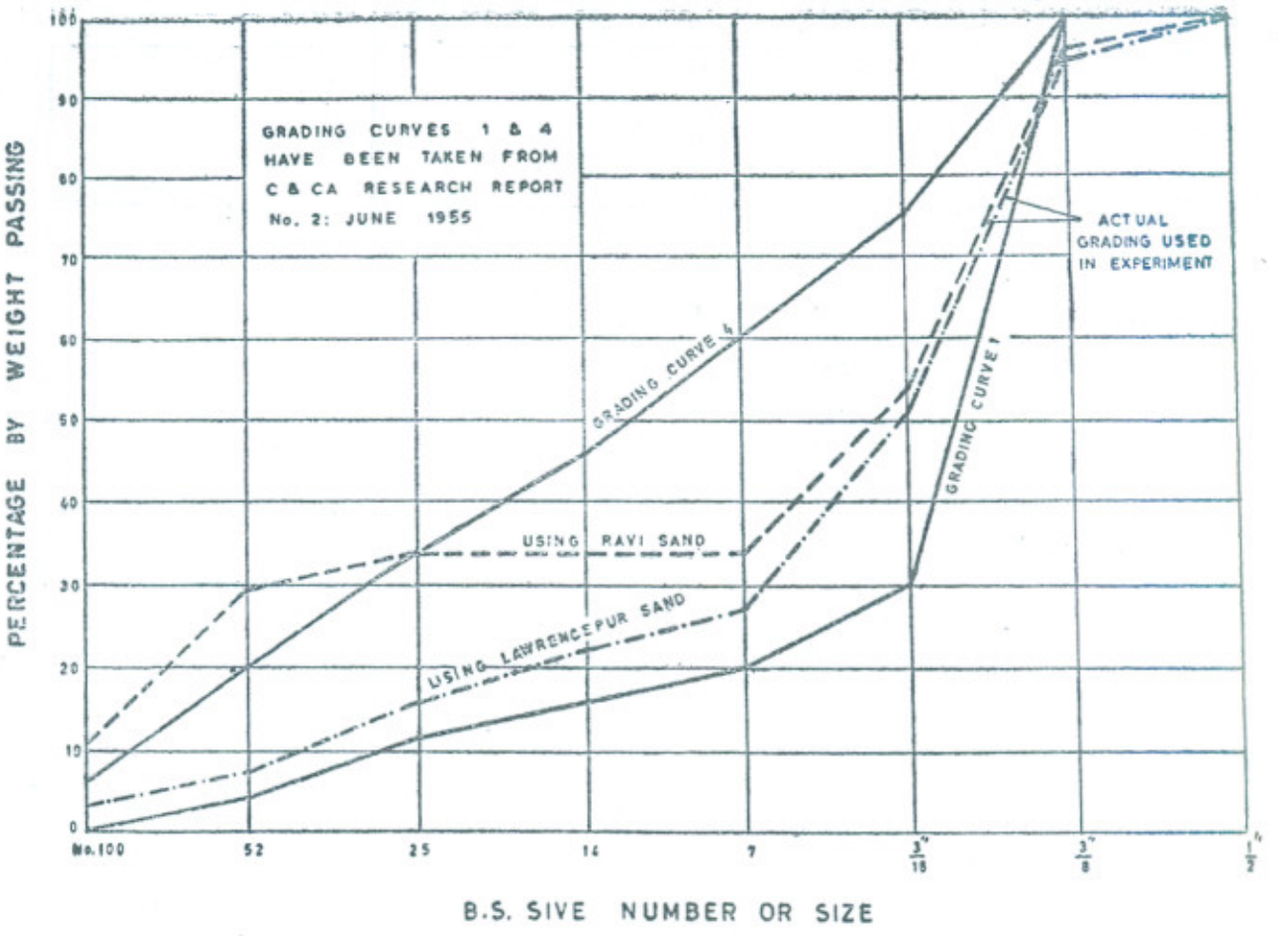


FIG No. 2 GRADING OF COMBINED AGGREGATES USED IN THE EXPERIMENT COMPARED WITH PUBLISHED REPORT

its grading was adjusted to the specified limits of the relevant B.S. 3797 : 1964 as shown in Table 2. An identical grade of natural stone aggregate from Usman Khattar was also prepared for making a comparison of strengths between the two concretes.

CONCRETE MIX

There can be several proportions with which available ingredients *viz.* coarse aggregate, fine aggregate, cement and water can be added to form a concrete mix. Economical proportioning of the ingredients and water is to be determined for achieving requisite properties of concrete in its plastic and hardened state. Methods have been prescribed under American and British practices for mix design of gravel concrete but no such procedure has been laid down for the Lightweight concrete. This is left to the manufacturers of lightweight aggregates who usually recommend standard mixes for concrete with their products. Therefore for a new product of lightweight aggregates, standard mixes are to be determined for required consistency and strength of concrete by testing various trial mixes in the laboratory. The present investigations are limited only to the nominal mix of 1 : 2 : 4 by volume mainly because this mix is popularly used in ordinary constructions in this country.

TABLE 2

Gradings of Aggregates Used.

B.S. Sieve Size or Number	Percentage by weight passing each sieve				
		Fine Aggregate		Combined Aggregate	
	1/2" crush coarse Aggregate.	Ravi	Lawrencepur	33% Ravi sand by wt. of total Agg:	30% Lawrencepur sand by wt. of total Agg :
1/2" ..	100	100	100	100	100
3/8" ..	94	100	100	96	95
3/16" ..	31	100	97	53	51
No. 7 ..	0	100	90	34	27
No. 14 ..	0	100	75	34	22
No. 25 ..	0	100	54	34	16
No. 52 ..	0	87	21	29	7
No. 100 ..	0	33.5	8	11	3

TABLE 3

Properties of the Experimental Concretes.

Type of Sand Used	Age (days)	W/C Ratio By Weight	Expanded Clay Aggregate Concrete			Gravel Concrete		
			Slump (in)	Density lbs/cft	Crushing Strength PSI	Slump (in)	Density lbs/cft	Crushing Strength PSI
RAVI	7	0.7	NIL	125.4	3125	NIL	152.3	2651
		0.8	NIL	124.6	2260	2¼	150.0	1729
		0.9	1½	124.9	1823	6	150.1	1219
		1.0	7	122.5	1458	9	148.3	1138
	28	0.7	NIL	127.7	3839	NIL	153.1	3240
		0.8	NIL	126.9	2771	2¼	150.8	2464
		0.9	1½	125.0	2151	6	149.5	2068
		1.0	7	122.9	1900	9	149.0	1803
Lawrencepur	7	0.7	NIL	130.4	2995	NIL	153.6	2313
		0.8	½	127.5	2063	2	151.9	1635
		0.9	1½	125.2	1427	5½	150.8	1094
		1.0	6½	123.4	1086	8½	149.9	875
	28	0.7	NIL	131.7	3714	NIL	154.2	3286
		0.8	1/2	129.2	2875	2	154.2	2333
		0.9	1½	127.5	2313	5½	151.8	1805
		1.0	6½	126.5	1927	8½	151.6	1474

The test cubes were made for water/cement ratio ranging from 0.7 to 1.0 by weight. The workability was estimated from the standard slump test as shown in Table-3. It may be noted that the aggregates used were dried in an oven and allowed to cool to room temperature before mixing water. The water/cement ratio therefore includes water absorbed by the aggregates.

MAKING OF TEST CUBES

Test cubes of 4'' size were made in accordance with the standard procedure laid in B.S. 1881 : 1952. The concrete was mixed by hand in a pan having a curved base. It was compacted in the moulds by vibrating with Kango electric hammer. The test cubes were stored in the laboratory free from vibrations and were covered with wet gunny bags for about 24 hours. Then the cubes were marked, demoulded and immediately submerged in a tank of clean water in the laboratory.

Twelve cubes were prepared with each consistency and each type of sand to obtain average crushing strength of six after 7 and 28 days. The same number of cubes were prepared with bajri to compare strength of lightweight and gravel concrete.

The temperature in the laboratory while making and curing the cubes was between 70°F to 93°C while the humidity ranged between 38% to 63%.

WET DENSITY OF CONCRETE

The cubes were weighed in saturated but surface dry condition at the age of 7 days and 28 days before testing their crushing strength. The wet density worked out is given in Table 3.

CRUSHING STRENGTH OF CONCRETE

Each test cube was then crushed in the Compression Testing Machine for determining the compressive strength according to the procedure specified in B.S. 1881 : 1952. Average crushing strength was worked out on the basis of mean strength of the six test cubes for each consistency and results set in Table 3. A relationship between the density and cube crushing strength at 28 days age of "Lightweight Concrete with Locally Expanded Clay Aggregate" and "Gravel Concrete" is shown in Fig. 3. The relationship between total water/cement ratio and crushing strength of "Lightweight Concrete with locally expanded clay aggregate" and "Gravel Concrete" using Ravi and Lawrencepur sand respectively in each type of concrete is indicated in Fig. 4. The relationship between net water/cement ratio (obtained after deducting water absorbed by coarse aggregates) and the crushing strength of concretes is given in Fig. 5.

DISCUSSION

The expanded clay aggregate manufactured in the Pilot Plant at Lahore with water absorption of 7.1%, bulk density of 56 lbs/cft. and specific gravity of 1.7 is about 36% lighter than bajri which has the bulk density of 88 lbs/cft. and specific gravity 2.69.

The density of the "Lightweight Concrete with locally expanded clay aggregate" is lower than that of "Gravel Concrete" of the equivalent strength. For example, at a strength ranging between 2000 lbs/sq. in. to 3000 lbs/sq. in. the density of lightweight

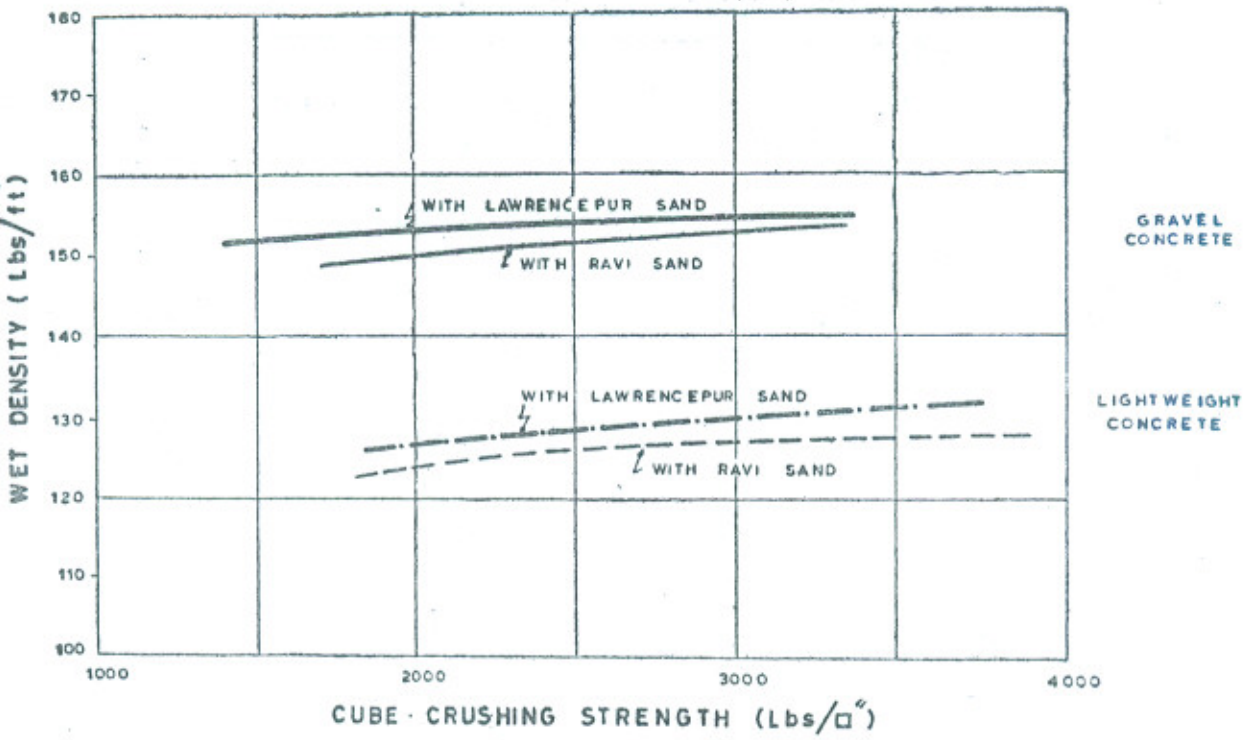


FIG No. 3 RELATION BETWEEN CUBE CRUSING STRENGTH AND WET DENSITY AT 28 DAYS OF LIGHTWEIGHT CONCRETE WITH LOCALLY EXPANDED CLAY AGGREGATE AND GRAVEL CONCRETE, 1:2:4 NOMINAL MIX BY VOLUME USING RAVI / LAWRENCE SAND.

concrete ranges between 122 lbs/cft. to 125 lbs/cft. while the density of the gravel concrete of the same strength ranges between 145 lbs/cft. to 147.2 lbs/cft. This means that the lightweight concrete has 16% less self weight than the gravel concrete at the said range of strength. It is also noticed that density of concrete with Ravi sand is lower than that with Lawrencepur sand.

It will be seen from Fig. 4 that the strength of gravel concrete for the same water/cement ratio is less than the concrete made from expanded clay aggregates. This can be attributed to high absorption of water by the expanded clay aggregates which in turn reduces the net water/cement ratio. This presumption is also confirmed from Table 3 which shows that the slump of lightweight concrete is less than that of gravel concrete in spite of higher apparent water/cement ratio. In order to remove the ambiguity, the total water/cement ratios have been converted to net water/cement ratios (Table 4) on the assumption that the aggregates absorb water up to the final setting of cement *i.e.*, 24 hours. In deriving net water/cement ratio, the percentage of water absorbed in 24 hours shown in Table 1 and Fig. 1 have been accounted for. Water absorbed by the fine aggregate has not been accounted for because it is a common factor in both types of concretes. A relationship between net water/cement ratio and cube crushing strength of "Lightweight Concrete" and "Gravel Concrete" using Ravi sand and Lawrencepur sand as fine aggregate in each type of the concrete mixes is shown in Fig. 5. It will be seen that the 28 days' strength for a given net water/cement ratio is slightly less for lightweight concrete than gravel concrete.

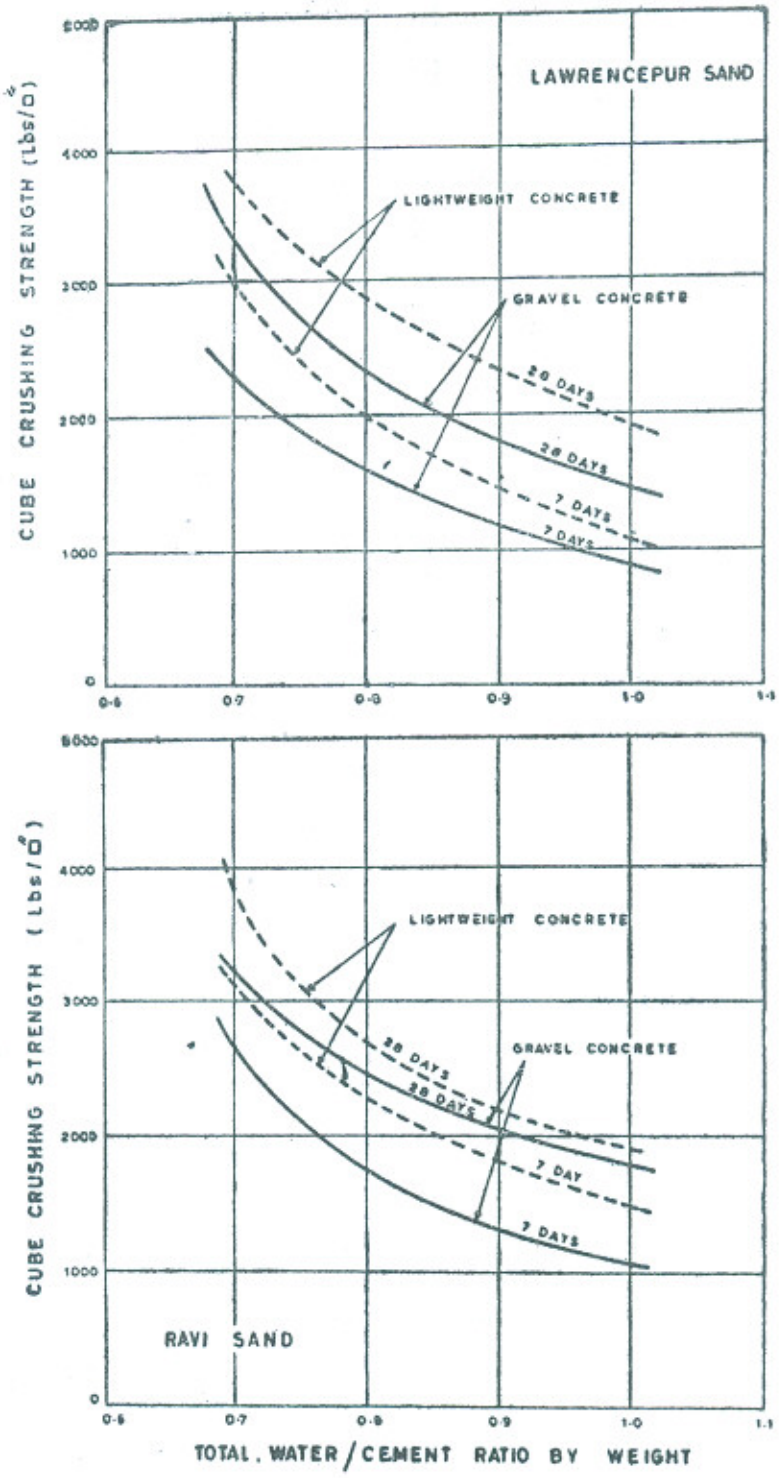


FIG NO. 4 RELATION BETWEEN TOTAL WATER-CEMENT RATIO AND CUBE CRUSHING STRENGTH OF 'LIGHTWEIGHT CONCRETE WITH LOCALLY EXPANDED CLAY AGGREGATE AND GRAVEL CONCRETE' 1:2:4 NOMINAL MIX BY VOLUME

TABLE 4

Derived Net Water-Cement Ratio.

Total W/C ratio by weight	Net Water-Cement ratio by weight		Remarks
	Expanded Clay Aggregate Concrete	Gravel Concrete	
0.7	0.51	0.66	Net Water-Cement ratio $= (W \frac{w \times P}{100}) \frac{1}{C}$ where :
0.8	0.61	0.76	W = Total wt. of water.
0.9	0.71	0.86	w = weight of coarse aggregate.
1.0	0.81	0.96	P = Percentage water absorbed by coarse aggregate.
			C = Weight of Cement.

TABLE 5

Comparison of Gravel Concrete Using Lawarencepur Sand with Published Data.

Experimental Results				C & C A Research Report No. 2		
W/C ratio by wt.	Slump (in)	Agg. cement ratio	28 days' crushing strength p.s.i.	Degree of workability	Agg. cement ratio	Anticipated 28 days' crushing strength, p.s.i.
0.7	0	5.87	3286	Very low	5.3 to 7.9	3200
0.8	2	5.87	2333	High	4.7 to 5.8	2450
0.9	$5\frac{1}{2}$	5.87	1805	—Not applicable		1850
1.0	$8\frac{1}{2}$	5.87	1474	—Not applicable		1500

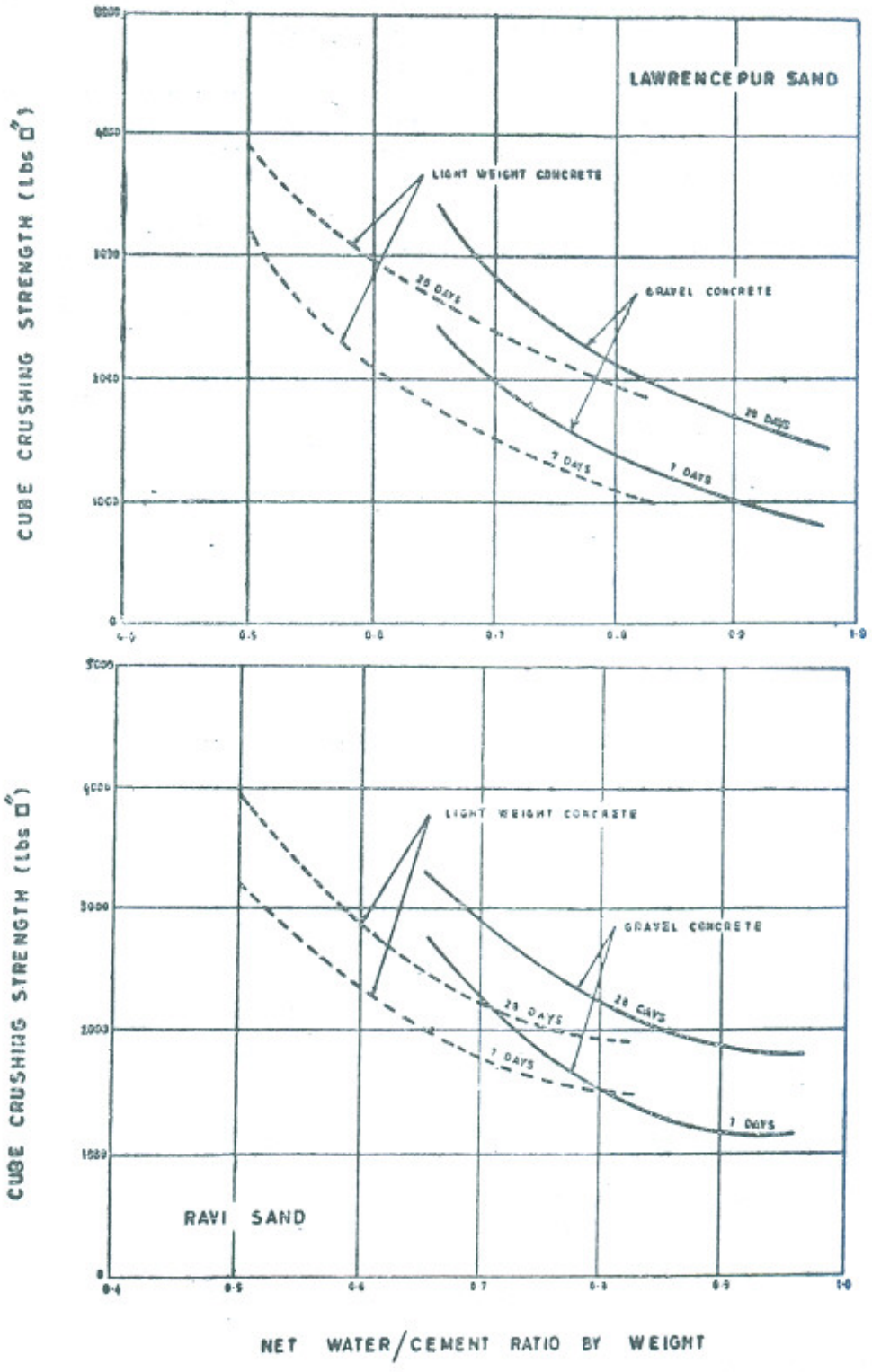


FIG No. 5 RELATION BETWEEN NET WATER CEMENT RATIO AND AND CUBE CRUSHING STRENGTH OF LIGHTWEIGHT CONCRETE WITH LOCALLY EXPANDED CLAY AGGREGATE AND GRAVEL CONCRET 1 2 4 NOMINAL MIX BY VOLUME

It will also be seen from Fig. 4 & Fig. 5 that the crushing strength increases as the water/cement ratio decreases. It was not possible to try water cement ratio less 0.7 as the slump noted was almost zero. Similarly water/cement ratio above 1.0 could not be tried due to high workability which is not desirable in actual concreting. It will be seen that for a given water/cement ratio, the strength of concrete with Ravi sand is slightly higher than with Lawrencepur sand. This is presumably due to the fact that coarse aggregates used were under 1/2" maximum size in which finer sand may be providing a better grading.

The concrete made from gravel aggregates has been compared with design of mix data given by McIntosh and Erntroy of Cement and Concrete Association London. A summary is given in Table 5 which shows that aggregate/cement ratio of 5.87 used in the experiments corresponds with the ratio obtained from the said report for very low and high degree of workability. This report limits the slump to only 4 in. for high workability. The higher slumps used in the experiments could not therefore be compared. The Road Note No. 4, however, permits up to 7 in. slump for high workability but the minimum size of aggregates prescribed being 3/4 in. is inapplicable to the case under discussion.

It will also be seen from Table 5 that experimental crushing strength of gravel concrete corresponds to the 28 days' strength anticipated from curves given in Road Note No. 4 for various water/cement ratios.

CONCLUSION

The Lightweight Expanded Clay Aggregate manufactured in the Pilot Plant at Lahore has suitable qualities for replacing heavier and more costly gravel from concrete. The lightweight concrete made from locally expanded clay aggregates and natural sands in the ratio of 1 : 2 : 4 by volume gives more or less the same crushing strength as that of concrete made from gravel aggregates. The economy due to reduction in self weight of concrete and lower cost of expanded clay aggregates (which has been given in a separate paper entitled "Pilot Plant for producing Expanded Clay Aggregates") will attract the industrialists of this country to come forward in this new venture.

ACKNOWLEDGEMENT

The authors are thankful to the staff of Building Research Station who helped in various tests.

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Thermal Insulation of Buildings

By **Shaukat Ali, B.Sc. (Engg.), Civil A.M.I.E. (Pak).**

Very little attention is being paid towards thermal insulation both in the private and public sector of building construction. This paper endeavours to emphasize its necessity and suggests some simple methods of Thermal Insulation using Indigenous Materials hitherto less frequently used. Besides discussing the merits and demerits of each suggested method, the paper also highlights some vital comfort contributing factors in building construction.

Thermal Insulation of Buildings

Partial or complete elimination or isolation of extremes of weather within a dwelling, place of residence or a building can be termed as thermal insulation of buildings. Homo Sapiens had recognised the importance of insulation right from the day they started covering themselves with skins of hunted animals or leaves of trees. The comfort or cosiness given by these crude clothes acting as a sort of insulation against the inclement cold or the scorching sun made them understand the necessity of providing some kind of protection for their dwellings against heat and cold.

Early examples of thermal insulation of buildings can be found among primitive peoples of the various parts of this globe. Some used thatched huts with roofs of straw, cornstalks or hay and walls of mud. Others used tree branches and such other materials as locally available. Denizens of the cold regions used snow itself to protect themselves from the cold weather. By the process of trial and error man began to realize the basic fact about thermal insulation that all materials offer some resistance to the flow of heat and that resistance increases with the thickness of the material used.

Gradually realizing the sense of increased resistance offered by a given thicker material, man began to use thick walls and thick roofs. Man's experience with low roofs in hot regions did not prove comfortable as compared to relatively high roofs. Besides, given as he was to living most of the time in the open, early man, especially in hot regions, got a feeling of suffocation from low ceilings. Thus high roofs became popular in hot regions. For centuries this practice remained

in vogue in most parts of the tropical and sub-tropical world. But as the cost of construction soared up a man was compelled to restrict the thickness of walls and roofs and the height of rooms. In a country like ours, where air-conditioning facility is a luxury, this type of building construction has led to great inconvenience and uncomfortability.

Need for Thermal Insulation

Dazzled by the brilliance of the scientifically and materially advanced West, we have blindly followed them and adopted their structural and architectural elements. This has caused considerable uncosiness and made our houses completely devoid of comfort. Without air-conditioning the new dwellings in most of the localities in West Pakistan are unlivable and uninhabitable in sultry summers when the roof temperature goes as high as 160°F and except for southern and northern walls, the eastern and western walls become alternately so hot that temperature inside the room shoots to over 100°F. In West Pakistan, the somewhat tolerable room temperature with light summer clothing and forced air movement of electric fan can be as high as 90°F. According to Ernest. J. Mc Cormick[1], the most popular summer temperatures range from 69°F to 73°F and winter from 67° to 68°F effective temperature; where effective temperature is an arbitrary index which combines into a single value the effect of temperature, humidity and air movement on the sensation of warmth or cold felt by the human body and is equal to the temperature of still saturated air which would induce an identical sensation. Winslow Herrington and Gagge[2] in their paper, "Relations Between Atmospheric Conditions, Physiological Reactions and Sensations of Pleasantness" find comfort to be closely related to the skin temperature. According to them comfort is maximum in the range of skin temperatures from about 91° to 93°F. Nevertheless when the difference between the actual room temperature and the comfortable room temperature is high, as in West Pakistan, man cannot achieve a balance between heat gained through the environments and heat lost from the body to the surroundings and cannot help feeling uncomfortable. According to Dr. Lee[3] an average adult man produces 290 Btu/hr even at rest. He also gains heat, in a room, from the reflected radiant energy of the sun and from the ambient hot air. He loses heat through the forced-air-movement of an electric fan, perspiration and evaporation of the sweat. When a man fails to lose heat at the same rate he is gaining, he is likely to suffer from sunstroke or run a high fever. With comparatively thin walls, and roofs and practically no thermal insulation, the living conditions in summer in West Pakistan are becoming too unbearable and there is a need to adopt a realistic approach to this problem.

Whatever the orientation of a dwelling, apartment or a house, the roof as well as the eastern and western walls require maximum attention towards thermal insulation. Because these are the three elements of a building which are invariably exposed to the maximum radiation load from the sun during summer and their negligence may lead to the harshest unpleasantness and uncomfortability. Besides it has been observed that maximum receipt of solar radiation on the earth's surface over the whole of a clear summer day is not at the equator but somewhere between 30° and 45° latitudes. It will be interesting to note that West Pakistan. lies between 24° to 37° N. This all the more

necessitates the provision of thermal insulation.

Indigenous Insulating Materials

From the very beginning, light porous or fluffy materials as fur, cotton, wool, straw, grass, feathers and dry snow have been used for insulation purposes. Cork as a thermal insulation material was only first referred by Pliny in the first century of the Christian Era. Many of the above insulators are very expensive and too costly to be used in economical construction. In other countries this hundle has been overcome to some extent by manufacturing various commercial thermal insulating materials such as mineral wools, cement-fibre-blocks, cellular rubber blocks and insulating blankets. In our country though such insulating materials as "Thermopore", cellular rubber blocks and insulating building boards are being manufactured but they are very expensive and their use so far is restricted to air-conditioning, refrigeration, acoustics and costly packing. Under these circumstances, the following indigenous thermal insulating materials some of which were used by our forebears one way or the other can also be used to-day in modern buildings. Many of them are very economical and easily procurable.

1. **Mud or Clay** is invariably being used in all roofs insulations at present. This all-purpose material can be used both for the insulation of walls and roofs. In case of roofs, its insulation is marked only when it is in sufficient thickness but that makes the structural roof unit too heavy though it is in itself quite inexpensive. The coefficient of thermal conductivity of mud or clay increases with the moisture content and compaction. At 14% moisture content, the coefficient of thermal conductivity is 2.60 btu/hr/sq ft/in/F°. In case of walls, mud or clay walls with brick or stone facing can be built but their thickness reduces the available floor space.

2. **Saw-dust and wood shavings.**—Both the materials are abundantly and cheaply available and possess low thermal conductivity when dry but as loose-fill materials they require other than conventional arrangements for their utilization and as such are likely to be expensive. With some gelatinous cement-material, natural or synthetic, it should be possible to make very light and porous sawable slabs which could be used for insulation purposes on the same pattern as chipboards or other wood-fibre boards but having low flexural strength and thickness ranging from 3" to 6". In the absence of the above wood-fibre slabs, wood shavings or saw-dust can be effectively utilised by evenly placing the required thickness of saw-dust or shavings over a given roof into confined places and covering it with some water-proof membrane, like polythelene sheet, bituminized roofing felt etc. before it is covered with earth and brick-tile flooring.

3. **Rice-husk.**—Rice is extensively grown in both the wings of Pakistan and consequently there is no dearth of rice-husk. Presently rice-husk is being used as a fodder for the cattle its potentialities as a good insulating material have not been fully explored. Apart from its use on the same lines as wood-shavings or saw-dust, it can be made into blocks with cement and laid over roofs directly. The thermal conductivity of rice-husk-cement blocks is quite low and can increase with the ingress of water. Covering of rice-husk-blocks with some water-proof membrane or with cement plaster therefore cannot be precluded if the penetration of water is to be avoided.

4. Rice-Stalks, Wheat-stalks and Hay.—Rice-stalks locally known as "Pirali" and wheat-stalks are excellent thermal insulating materials and so is hay and are abundantly available in West Pakistan. Modern agricultural equipment while thrashing rice or wheat can pack the stalks into slabs of flags of convenient thickness. These flags or slabs can be used very effectively as roof or wall insulation. In the absence of such agricultural machinery hay or stalks can be made into insulating blankets with the help of jute or cotton chords by semi-skilled village labour. If properly made into blankets and protected from the infiltration of water, their resistance to the penetration or heat can be as high as that of cork. Among the indigenous thermal insulating materials, rice-stalks, wheat stalks, dry grass or hay and sea-grass are the most promising economical material which can be used for thermal insulating purposes.

5. Sarcanda.—It is a large reed-like plant with jointed stems which has been used for centuries in Pakistan both as a covering and insulating material for roofs and is still in vogue in villages. Sarcanda stems possess some flexural strength and can be used as a cheap substitute for wooden planks for batten type roofs. At present it is being used for the manufacture of "Chicks" or indigenous blinds but it has also a great potential as a thermal insulating material. Crude sarcanda can be made into blankets like "chicks" and laid over roofs directly. Several layers of these blankets can have adequate thermal resistance.

6. Cellular Concrete.—Using indigenous foaming agent "Balcrete", cellular concrete or light weight concrete can be manufactured and used for roof or wall insulation. Cellular concrete can be manufactured from 40lbs/cft to over 70 lbs/cu.ft. density with cement sand ratios varying from 1 : 1 to 1 : 4 and the quantity of "Balcrete" to be roughly as many ounces as the number of gallons of water required to be used for the proper wetting of the sand and hydration of cement. Like other porous insulating materials its thermal conductivity increases with the density but it is not very low even at the lowest density. Besides it is somewhat expensive as compared to other indigenous insulating materials. Its use, therefore, is likely to be popular with foreign consultants who do not possess adequate know-how of the local materials. The following field samples of cellular concrete were produced at the Lyallpur Agriculture University for thermal insulation of its campus buildings The results are reproduced below:—

Samples of Cellular concrete produced for Lyallpur Agricultural University Campus with different cement sand ratios.

Cement/sand ratio by wt.	Water	Balcrete	Mixing time	Density	Thermal conductivity.
1 : 1	3.75 gals.	3.75 oz.	2 minutes	94 lbs/cuft.	2.51
1 : 0	2.75 gals.	3.25 oz.	2.5 minutes	78 lbs/cuft.	2.20
1 : 3	2.50 gals.	2.5 oz.	2 minutes	48 lbs/cuft.	1.45

Coefficient of Thermal Conductivity and Conductance

The coefficients of thermal conductivity of any material can be defined as the amount of heat expressed in British Thermal units or Btu transmitted in one hour through one square foot of a homogenous material one inch thick for a difference in temperature of one degree Fahrenheit between the two surfaces of the material: whereas conductance is the amount of heat in Btu transmitted in one hour through one square foot of a non-homogeneous material or combination of materials for the thickness under consideration for a difference in temperature of one degree Fahrenheit between the two surfaces of the material. Both the coefficient of thermal conductivity and the conductance can be determined by hot-plate or hot box apparatus or by Nichols heat meter. Determination of the heat transmission data is a highly specialized job and cannot be performed by an ordinary laboratory. Even in the United States such accredited or authoritative laboratories whose data may be accepted as reliable are very limited. In view of this it is futile to get heat transmission data locally unless the laboratories are elaborately equipped with highly sensitive equipment and the staff is adequately experienced. For calculating the overall coefficient of heat transmission of a given wall or roof insulation arrangement, the coefficient of thermal conductivity and conductances of the various materials are given below. Thermal conductivity and conductances of the indigenous materials are only approximate. Exact values can be obtained by submitting samples of the materials to the U.S. Bureau of Standards or to the American Society of Heating and Ventilating Engineers Research Laboratory or similar other international testing agencies:—

Co-efficient of Thermal Conductivity (k) and the conductances (c) of the various Building Materials.

S. No.	Material	Density LBS/Cuft.	Mean Temp oF of	Conductivity or conductance k	c	Reference
1	2	3	4	5		6
1.	Concrete	142	75°	12.0		1. ASHVE-Guide.
2.	Common Brickwork	—	—	5.0		2. ASHVE-Research Laboratory.
3.	Cement mortar	120	—	12.0		3. U.S. Bureau of Standards.
4.	Air space 3/4" or more in width bounded by ordinary materials	—	—	—	1.10	4. National Bureau standards Washington D.C.
5.	Cork board	7.0	90	0.27		5. PAUL DUNHAM GLOSE Building Insulation 1952—American Technical Society-4th Printing 1952.

1	2	3	4	5	6
				k | c	
6.	Still Air with ordinary materials	—	—	—	1.65
7.	15 mph wind velocity over ordinary material	—	—	—	6.00
8.	Rice-husk blocks or slabs	24.0	72	0.46	
9.	Pirali, rice-stalks, wheat-stalks and corn stalks etc.	10	80	0.34	
10.	Sarcanda	20	—	0.40	
11.	Saw-dust of various woods	12	90	0.41	
12.	Wood shavings of various woods	8.7	86	0.40	
13.	Jute.	6.0	90	0.27	
14.	6'' hollow clay Tile	—	—	—	0.64
15.	8'' hollow clay Tile	—	—	—	0.60
16.	12'' hollow clay tile	—	—	—	0.58
17.	Cellular concrete	40	75	1.06	
18.	Cellular concrete	50	75	1.44	
19.	Cellular concrete	60	75	1.80	
20.	Cellular concrete	70	75	—	2.80
21.	Light weight concrete using bloated clay as aggregate	60	75	—	2.28
22.	Corrugated asbestos sheets	20.4	110	0.48	
23.	8'' hollow concrete blocks	—	—	1.00	
24.	12'' hollow concrete blocks	—	—	0.80	
25.	Asphalt	70	75	6.5	
26.	Bitumen or felt gravel surfaced	—	—	1.33	
27.	Cotton	6.0	90	0.25	
28.	Thermopore	7.10	—	0.28	
29.	Brick ballast	—	—	—	2.86
30.	Plywood 5/16''	—	—	—	2.56
31.	Terrazzo	—	—	12.0	
32.	Earth or clay with 14% moisture-content	—	—	2.60	
33.	Shisham	46	75	1.05	
34.	Deodar	36	—	0.91	
35.	Chipboards	30	80	0.70	
36.	Chipboards	40	80	0.84	
37.	Rice-husk-loose-fill	15	—	0.40	

Methods of Roof Insulation

The conventional method of roof insulation consisting of brick-tile flooring over 4-inches earth over Bitumen painted reinforced concrete or brick-work roof slab is widely being used throughout West Pakistan but its overall coefficient of heat transmission is not satisfactory. The only factor which supports it, is the cost of this type of construction and low diffiusivity. For low cost housing the conventional method can be used for the sake of economy but where some comfort is desired or the occupants are to be protected from the penetration of the excessive heat, the following roof insulation methods shall be found to have more comfort-value.

I. Rice-husk Block Insulation.—Pre-cast rice-husk-cement blocks 2 ft. square in size and 6 inches in thickness can be laid directly over the roof with ordinary cement sand mortar. In order to prevent the ingress of water the surface of the blocks can be treated with a mastic compound, bituminized roofing felt, jutoid or can be plastered with 1:3 cement sand mortar, well trowelled with a steel float and painted with bitumen. In order to have low diffusivity it is imperative to provide 4 inches of earth and brick-tile flooring over the treated blocks. This will also render the roof capable of being used as an open terrace. The comfort-value of this type of insulation can be judged from the fact that overall thermal conductivity of conventional roof is 0.34 Btu/Sqft/hr/F° whereas that of rice-husk block is only 0.064 Btu/Sqft/Hr/F°.

II. Cellular Concrete Roof Insulation.—Cellular concrete blocks of 4 inches to 6 inches thickness can be made by using indigenous foaming agent "Balcrete" and can be laid on roofs directly. Cellular, concrete blocks have also to be covered with a mastic sealing compound, bituminized roofing felt, or jutoid or can be plastered and painted with bitumen to avoid the penetration of water. Ingress of water is detrimental to the roof as it increases the load and to the insulating qualities of the concrete because water has a greater thermal conductivity than the intergranular air of the porous concrete. Using 6-inches cellular concrete blocks, the overall coefficient of heat transmission can be reduced to less than half the value of conventional insulation. In this case also, the cellular concrete has further to be covered with earth and brick-tile flooring to have low overall diffusivity.

III. Hollow-Tile Roof Insulation

This type of roof insulation consists of brick tile flooring over 4 inches, of earth over another layer of brick-tiles resting over bricks on edge 9 inches or 12 inches centre to centre depending upon the size of the tiles. This type of roof insulation is sometimes adopted by some foreign consultants working in our country in preference to the conventional type. But as compared to the increase in cost involved its overall coefficient of heat transmission is not low.

IV. Sarcanda Roof Insulation.—Sarcanda roof insulation has quite a low overall coefficient of heat transmission and its adoption can be very helpful in achieving the objective of comfortable housing. This type of insulation mainly comprises of several layers of crude sarcanda blankets covered with 4 inches earth and brick-tile flooring. If the overall coefficient of heat transmission of sarcanda insulation is calculated, it will be found to be about 1/4 that of the conventional type.

V. Rice-stalks or Hay-roof Insulation.—Of all the roof insulation arrangements suggested here this is most resistant to the penetration of heat and comparatively economical and calls for wide adoption. In this case sarcanda is replaced by jute-bound rice-stalks or hay blankets which are laid directly on the roof. In order to confine the rice-stalks or hay and to prevent heaving it is necessary to provide one or two layers of sarcanda blackets covered with 4 inches of earth and brick-tiles. Besides in all such types of roof insulations, the penetration of water to the rice-stalks or hay must be avoided as it would minimize the insulating effect and maximize the load on the roof.

VI. Clay-Pot Roof Insulation.—Earthen pitchers, bowls or pots can also be used for roof insulation purposes. Since earthen wares can be cheaply procured in this country, clay-pot insulation could have high potentiality as an insulating material provided its overall coefficient of heat transmission could be low. In this country this method has been used in private buildings and mosques with the preconceived idea that air-gap is a good insulator and that greater the gap, greater the insulation. This concept has proved fallacious. Experiments conducted by M. S. Van Dusen[5] of the U.S. Bureau of Standards have proved beyond doubt that air-space beyond 3/4 inches in width bounded by ordinary non-reflective materials does not practically decrease the heat transmission. This view is also supported by Frederick S. Merritt[6] and Dr. Lee[3] According to Dr. Lee the insulating value of an air-space is proportional to its thickness up to 0.25 in beyond this the insulating value increases less and less until any increase in thickness brings no gain in insulation. In view of this, clay-pot roof insulation is not as effective as hitherto considered. For the same reasons, cavity walls with air spaces more than 3/4 inches in width do not possess enough comfort-value.

VII. Composite Roof Insulation.—Composite roof insulation is an insulation combining two or more of the above described methods. In this case loose-fill materials like saw-dust, shavings or rice-husk etc. can be placed over confined roof compartments and then several layers of rice-stalk or sarcanda blankets can be provided before laying earth and brick-tile flooring. The compartments can be of one or two courses of bricks laid in mud mortar and suitably spaced. In small roofs compartments can be dispensed with; only peripheral confinement can suffice. If properly arranged composite insulation can have relatively better comfort-value because of the low conductivity of its components.

Heat Transmission

An arbitrary statement that sacrcanda insulation is more effective than, say, clay-pot insulation, will not be cogent unless it is supported by realistic calculations. For calculating the heat-transmission of a wall, ceiling, partition or window the following formula[7] can be used:—

$$q_o = A_r U_r (t_o - t_i)$$

where

q_o = heat transmitted or conducted through the roof or wall in Btu per hour.

A_r = Area of ceiling or wall in square feet.

U_r = Overall coefficient of heat transmission in Btu per square ft. per hr. per F° degree difference of temperature.

t_o = External temperature F°

t_i = Internal temperature F°

Evidently for a given ceiling area and temperature difference, heat transmission is dependent upon the overall coefficient of heat transmission and while selecting an insulating arrangement if we choose the one which has the lowest overall coefficient, the heat transmission will be the least. The Overall coefficient of heat transmission, therefore, is the primary parameter which determines the suitability of an insulation and recommends its adoption. In view of the above, the insulation arrangements suggested in this paper shall have no significance if their overall coefficients are not calculated. Keeping this in mind the overall coefficient of heat transmission of each type of insulation has been worked out below adopting the conductivities and conductances as given in the table above. For calculating the overall coefficient of heat transmission a generalized formula can be written as under:—

$$U = \frac{1}{\frac{1}{f_i} + \left(\frac{x1}{ki} + \frac{1}{a_1} + \frac{x2}{k2} + \frac{1}{a_2} + \frac{x3}{k3} \cdots \frac{1}{a_{n-1}} + \frac{xn}{k_n}\right) + \frac{1}{f_o}}$$

where

U = Over-all coefficient of heat transmission in Btu per sq. ft., per hr. per 1°F difference of temperature.

f_i = Inside surface conductance numerically equal to the amount of heat in Btu transmitted by radiation, conduction and convection from the surface to the air surrounding it or *vice versa* in one hour per sq. ft. of the surface per 1 °F difference of temperature.

f_o = External surface conductance defined as in case of f_i.

x_1 , x_2'.....x_n are the thicknesses of the various materials forming part of the insulation arrangement.

k_1 , k_2.....k_n are the coefficients of thermal conductivities of the materials, whose thicknesses are x_1, x_2.....x_n etc.
and a_1, a_2.....an—1 are the thermal conductances of the air spaces bounded by material of thickness x_1, x_2,.....x_n.

Using the above formula the overall coefficient of heat transmission of each type is now calculated. In all these calculations roof slabs have been assumed as 4 in thick, inside air as still and outside air as a wind having 15 mph velocity.

Applying the above formula we have,

1. Conventional Roof Insulation

(See figure I)

1	=	1.65
x_1	=	4 in
x_2	=	4 in
x_3	=	1.5
f_o	=	6.00
k_1	=	12.00
k_2	=	2.60
k_3	=	5.0 and $a_1, a_2 \ldots\ldots\ldots\ldots\ldots a_{n-1}=0$

Hence $$U = \frac{1}{\frac{1}{1.65}+\frac{4}{12.0}+\frac{4}{2.60}+\frac{1.5}{5.0}+\frac{1}{6.0}}$$

$$= 0.34 \text{ Btu/sq. ft/hr/F°}$$

2. Rice-husk Block Insulation.

In this case (See figure 2)

f_i	=	1.65..
x_1	=	4 in
x_2	=	6 in
x_3	=	2 in
x_4	=	3 in
x_5	=	12 in
and f_o	=	6.0 $a_1, a_2, \ldots\ldots a_{n-1}=0$
k_1	=	12.0
k_2	=	0.46
k_3	=	12.0
k_4	=	2.60
k_5	=	5.0

Hence $$U := \frac{1}{\frac{1}{1.65}+\frac{4}{12.0}+\frac{6}{0.46}+\frac{0.5}{12.0}+\frac{3}{2.60}+\frac{1.5}{5.0}+\frac{1}{6.0}}$$

$$\frac{1}{0.606 + 0.333 + 13.04 + 0.041 + 1.15 + 0.30 + 0.16}$$

0.064 Btu/sq ft./hr/F°

3. **Cellular Concrete Insulation** (See figure 3)

Using a cellular concrete of 40 lbs/cft. density and 6 in thick blocks, we have in this case:—

$f_1 = 1.65$ as usual
$x_1 = 4$ in
$x_2 = 6$ in
$x_3 = 1$ in
$x_4 = 3$ in
$x_5 = 12$ in $a_1, a_2 \ldots\ldots\ldots\ldots a_{n-1} = 0$

and
$k_1 = 12.0$
$k_2 = 1.06$
$k_3 = 12.0$
$k_4 = 2.60$
$k_5 = 5.00$ and $f_o = 6.0$

$$\text{Hence } U := \frac{1}{\frac{1}{1.65} + \frac{4}{12} + \frac{6}{1.06} + \frac{0.5}{12} + \frac{3}{2.60} + \frac{1.5}{5.00} + \frac{1}{6.00}}$$

: 0.121 Btu/sq.ft/hr/F°

4. **Hollow Brick Tile Insulation.**

In this case (See figure 4).

$f_1 = 1.65$
$x_1 = 4$ in
$x_2 = 6$ in ($4\frac{1}{2}'' - 1\frac{1}{2}''$)
$x_3 = 3$ in
$x_4 = 11$ in

and
$k_1 = 12.0$
$k_2 = 0.64$
$k_3 = 2.60$
$k_4 = 5.0$

and $a_1\ a_2 \ldots\ldots\ldots\ldots a_{n-1} = 0$, no air space.

$$\text{Hence } U = \frac{1}{\frac{1}{1.65} + \frac{4}{12} + \frac{1}{0.64} + \frac{3}{2.60} + \frac{1.5}{6.0} + \frac{1}{6.00}}$$

$$= \frac{1}{0.606 + 0.333 + 1.56 + 1.15 + 0.30 + 0.167}$$

0.243 Btu/sq. ft/hr/F°

CONVENTIONAL ROOF INSULATION

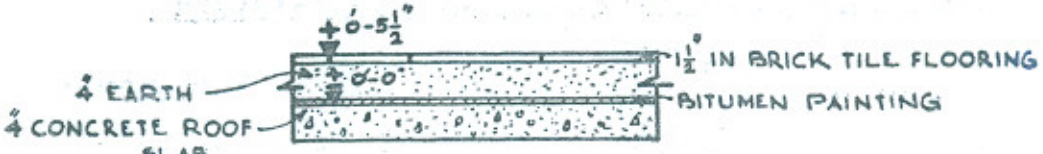


FIG: No. 1

RICE-HUSK BLOCK ROOF INSULATION

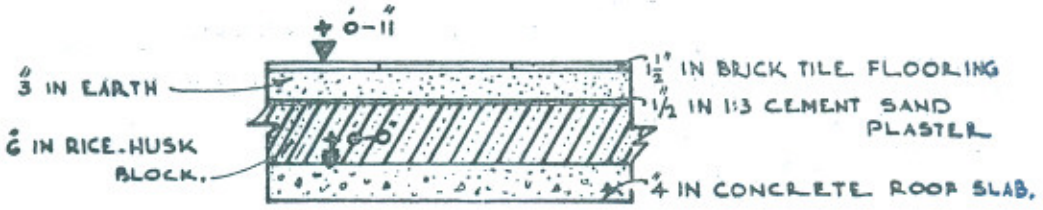


FIG: No. 2

CELLULAR CONCRETE INSULATION

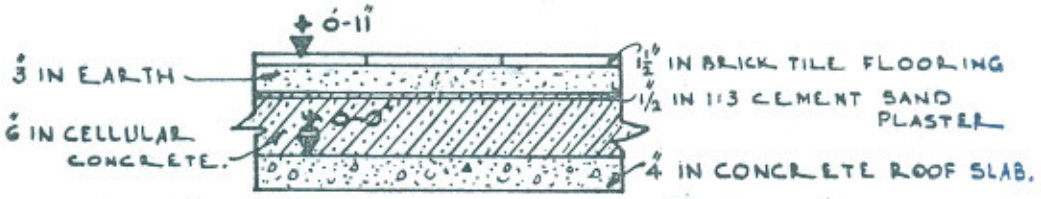


FIG: No. 3

HOLLOW BRICK TILE INSULATION

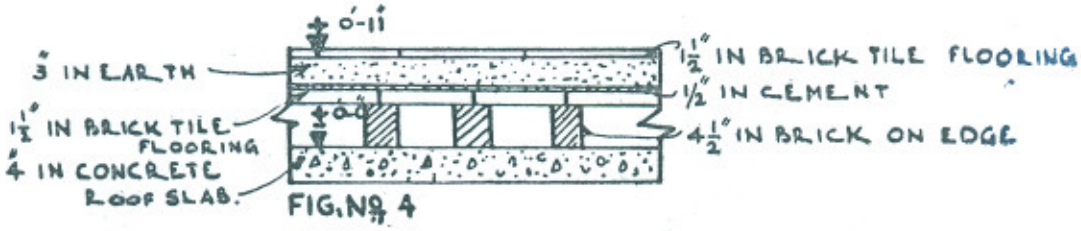


FIG. No. 4

SARCANDA ROOF INSULATION

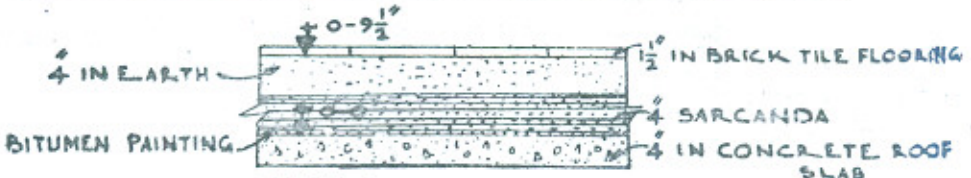


FIG: No 5

RICE-STALK OR HAY INSULATION

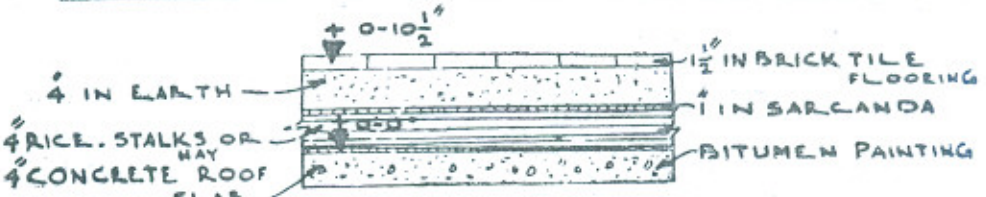


FIG: No 6

CLAY POT INSULATION

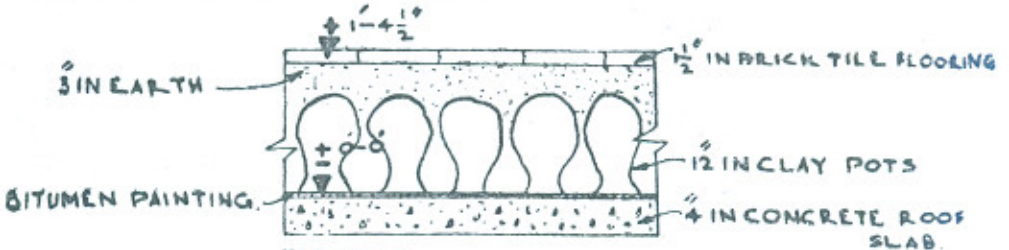


FIG: No 7

COMPOSITE INSULATION

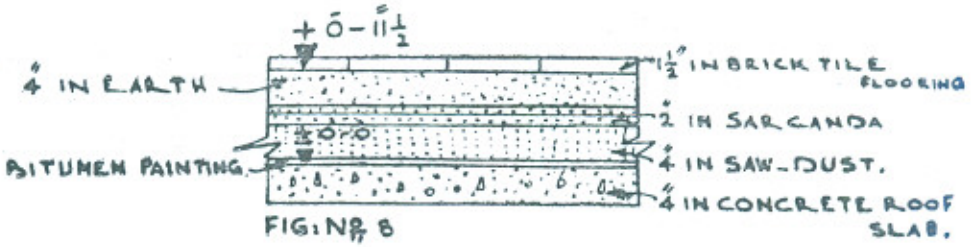


FIG: No 8

5. **Sarcanda Roof Insulation.** (See figure 5).

In this case f_i and f_o are the same as before and $a_1, a_2, \ldots\ldots a_{n-1}$ are zero.

And x_1 — 4 in
x_2 — 4 in
x_3 — 4 in
x_4 — 12 in
and k_1 — 12.0
k_2 — 0.40
k_3 — 2.60
k_4 — 5.00

$$\text{Hence U} = \frac{1}{\frac{1}{1.65} + \frac{4}{12.0} + \frac{4}{0.40} + \frac{4}{2.60} + \frac{1.5}{5.0} + \frac{1}{6.00}}$$

: 0.077 Btu/sq.ft/hr/F°

If the thickness of the Sarcanda Blankets is increased from 4 in to 6 in the overall coefficient can be further reduced.

6. **Rice-stalk or hay Insulation.** (See figure 6).

In this case as in previous cases the insulation provided by bitumen painting is ignored being insignificant.

Now f_i — 1.65 and f_o = 6.0
and x_1 — 4 in
x_2 — 4 in
x_3 — 1 in
x_4 — 4 in
x_5 — $1\frac{1}{2}$ *in*
and k_1 — 12.0
k_2 — 0.33
k_3 — 0.40
k_4 — 2.60
k_5 — 5.00

$$\text{Hence U} = \frac{1}{\frac{1}{1.65} + \frac{4}{12.0} + \frac{4}{0.33} + \frac{1}{0.40} + \frac{4}{2.60} + \frac{n1.5}{5.0} + \frac{1}{6.00}}$$

= 0.057 Btu/sq. ft/hr/F°,

7. **Clay — Pot Insulation.** (See figure 7).

Ignoring bitumen painting on slab.

we have

$$f_i = 1.65, \qquad f_o = 6.00$$

and

$$x_1 = 4 \text{ in}$$
$$x_2 = 12 \text{ in}$$
$$x_3 = 3 \text{ in}$$
$$x_4 = 12 \text{ in}$$

and

$$k_1 = 12.0$$
$$k_2 = 0.40 \text{ for the total thickness.}$$
$$k_3 = 2.60$$
$$k_4 = 5.0$$

$$\text{Hence } U = \frac{1}{\frac{1}{1.65} + \frac{4}{12.0} + \frac{1}{0.40} + \frac{3}{2.60} + \frac{1.5}{5.0} + \frac{1}{6.0}}$$

: 0.198 Btu/sq. ft/hr/F°

If smaller pots of 6 in height are employed the coefficient will be still higher and will not be worth adoption.

8. Composite Insulation. (See Figure 8)

Assuming brick compartments at 6 ft centre to centre and ignoring their existence for the purpose of calculations we have

f_i — 1.65 , f_o = 6.00

And

x_1 — 4 in
x_2 — 4 in
x_3 — 2 in
x_4 — 4 in
x_5 — 11 in

and

k_1 — 12.0
k_2 — 0.41
k_3 — 0.40
k_4 — 2.60
k_5 — 5.00

$$\text{Hence } U = \frac{1}{\frac{1}{1.65} + \frac{4}{12.0} + \frac{4}{0.41} + \frac{2}{0.40} + \frac{4}{2.60} + \frac{1.5}{5.0} + \frac{1}{6.00}}$$

$$= \frac{}{0.606 + 0.333 + 9.75 + 5.00 + 1.54 + 0.30 + 0.167}$$

$$= 0.056 \text{ Btu/sq. ft/hr/F°}$$

The cost per square foot of each type of roof insulating excluding the cost of slab, and other vital details of each type of insulation are abstracted in the following table:—

S. No.	Description	Coefficient of overall Thermal Conductivity.	Wt. per Sq. ft. of Insulation Lbs.	Cost per Sq. ft. of Insulation (Rs.)
1.	Conventional Roof Insulation.	0.34	52	0.90
2.	Rice-husk block roof Insulation.	0.064	59	2.75
3.	Cellular Concrete Roof Insulation	0.121	67	3.00
4.	Hollow Brick Tile roof Insulation.	0.243	74	1.85
5.	Sarcanda Roof Insulation	0.077	60	1.50
6.	Rice-stalk or hay Roof Insulation.	0.057	57	1.20
7.	Clay-Pot roof Insulation.	0.198	47	1.20
8.	Composite Roof Insulation	0.056	60	1.35

Conductivity and Diffusivity

It is of paramount importance to bear in mind that for the proper thermal insulation of buildings it is essential that not only the overall coefficient of heat transmission should be low, the overall thermal diffusivity should also be low. Thermal diffusivity is the rate at which heat will spread through a material when newly applied. It depends upon thermal conductivity, density and specific heat of a material. All those materials of low density which possess low conductivity have high diffusivity. It is in view of the above that in all insulation arrangements recommended in this paper light fluffy materials of low density like rice-husk, rice-stalk, hay, sarcanda, cellular concrete and rice-husk blocks have invariably been covered with materials of moderate density to strike a balance between conductivity and diffusivity. The role of diffusivity will be clear from the following explanation:

When heat is applied to a material some of it is used up in warming the particles of the outer surface, the remaining is spent in warming the particles of the next layer and the subsequent layers. In this way the warming up proceeds layer by layer. The conductivity determines how easily heat will pass from a warmed layer to the next unwarmed layer. But if the material is such that when heat is applied to it, major portion of the heat is spent up in warming the Ist layer and a minor portion is left for warming the subsequent layers the flow of heat will be delayed. This is what happens with materials of low diffusivity like clay, earth, bricks or stones. These materials may have high conducivity but in view of their low diffusivity if they are employed in sufficient thickness they are better than cork itself so far as thermal insulation of buildings is concerned. This explains the comfort-value of thick clay, stone or brick walls and roofs.

Thermal Insulation of Walls

Where such natural solar radiation interceptors as trees, bushes or shrubs are not available, eastern and western walls should be

provided with perforated concrete or brick grilles or fixed louvres so oriented as to protect the walls from the direct solar hit. All the windows on these two sides also need to be protected from the sun by providing venetian blinds or wooden louvres on the external side. In their paper "Field Study of Office Building Cooling" Walker, Sanford and Wells[8] found approximate values for solar radiation through glass as 150 Btu/sq./ft./hr. When the Window was protected from direct sunlight the heat gain was reduced to 4 Btu/sq. ft./hr. Walls can also be insulated by having a cavity between them of width not more than 3/4 inches if it is to remain airspace and as much as convenient if it is to be filled with rice-husk, saw-dust or similar loose-fill material. The air space of cavity can be increased with advantage if convection can be induced in the Air-Space through ample ventilation. It is important to mention here that no roof or lintel projections should be provided on the eastern and western walls as they are not likely to intercept any sunlight but their provision on the southern and northern walls can be very helpful. According to Dr. Lee, the best orientation, for the purpose of protection of walls from the direct solar radiation, will be of a tall building with long axis running east-west and having least width.

Other Comfort-contributing factors

The comfort-value of a building can also be enhanced by reducing the heat gained from solar radiation through external convection. External convection can be effected by omitting obstructing parapets, maintaining wind lanes between neighbouring buildings, eliminating dead areas between adjacent structures, making a tall building and locating a building at such a raised or situated place where there is always some wind blowing. Similarly, controlled ventilation will be vitally needed if the benefit of the thermal insulation are to be fully availed of.

The entry of hot air during hot day time must be minimized and the entry of cool air at night must be promoted. Another very effective approach in this respect is to provide an underground basement and to manage a draft of air to pass through a tunnel at about 12 feet below ground level leading to the basement and subsequently to all the important portions of the house and then to a chimney. Such houses shall be found to be cool in summer and warm in winter. Reflectivity and emissivity of the wall or roof surface are two additional factors which can also contribute to the overall cosiness for the dwellers of a building. Because if the roof or wall surface is selected in such a way that it reflects most of the incident radiation and then also easily remits the heat absorbed, there will be less rise of temperature. To some extent this can be done by whitewashing or painting with aluminium paint.

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(*Continued from page* 38)

At the design conditions the approach velocity is 2ft/sec. The velocity in the culvert is 12.45 ft/sec. As the approach depth falls, the velocity also decreases, but not linearly.

$$\frac{v_1}{v_2} = \left(\frac{y_1}{y_2}\right)^{2/3}$$ if n remains constant.

The design can accept quite a number of limitations. For example, if the invert of the culvert is limited to R.L. 98, then the design flow through the culvert is $3.33\sqrt{32 \times 3.33} =$ 34.4 cusecs/ft. Thus a culvert 17.5 ft wide is required to carry the 100 ft. flow. Alternatively, if it is required to use 10 ft wide culverts, they must be spaced (or will collect) at $\frac{344}{6} =$ 57 ft centres and the approaches designed accordingly.

This hydraulic design procedure appears to offer the complete flow answer, but the success of the design will depend largely on the cost of the approach works.

Memorandum on Class-I Status for Graduate Engineers in West Pakistan

This memorandum was issued by Mr. Ashfaq Hasan, President of the Punjab Gazetted Engineers Association. This has been forwarded to the Government for consideration. The memorandum is very informative and useful for the In-Service Engineers.

Background

The Engineers have been playing a pivotal role in economic uplift of our country and it is only due to their hard work and perspiration that Pakistan has come to be recognized in the International field as a model Developing State. The phenomenal economic growth and rise in per capita income are the direct result of Engineers' efforts in various sectors of economy. And yet it should be strange that this corpse of Nation builders is not rewarded by the administration. In fact the conditions of service for the Engineers are so humiliating that the talent is being positively repulsed from this profession. This is something quite grave and the Association is deeply concerned about it. If we are to continue our march towards self sufficiency, if the aim is to convert all deserts and barren parts into fertile tracts, if the emphasis is to increase productivity and reduce cost of living index, if the object of providing food, clothing and shelter to every individual is to be fulfilled, then the technology must receive topmost priority in the Government Programmes. Mere allocation of high priority is meaningless if the technologists are not given due recognition and due place in the administration to attract the talent. In other words, service conditions for the Engineers should at least be equal, if not better, than the highest Public Service in the country.

The Association recalls the press reports of May 1969 when a high level meeting of the Engineers representatives with the Chief Secretary was reported to have conceded this demand. But in spite of lapse of over a year, the Government has not been able to take any final decision. While a similar demand of graduates in Medicine, Dentistry has been conceded. The silence of Government about Engineers has caused a wave of great frustration amongst its ranks. The Association has assessed the situation which appears to be quite tense and may force the young Engineers to adopt some drastic measures in disgust. It is therefore imperative that the

Government should take immediate decision on this long-outstanding issue without going through the usual delaying mill of forming a Committee or study group.

The Problem

At present, the qualified Engineers are inducted into Government service through three distinct channels *viz*:

(*i*) as temporary Engineers,

(*ii*) as Assistant Engineer in Class II,

(*iii*) as Assistant Executive Engineer in Jr. Class I.

The selection for all the appointments in the initial grade is made through the Public Service Commission. All the officers, irrespective of the service they may belong to, perform exactly the same duties and functions at various appointments. But there is a considerable disparity in pay, status and prospects of promotion between Class-I officers and those from Class-II and temporary Engineers. For instance, officers recruited directly in Class-I service may get promoted to senior scale in 4 to 5 years while officers belonging to Class-II and temporary service have stagnated for over 12 years before getting promotion to Senior Scale. Further promotions to the grade of S.Es and Chief Engineers are only reserved for officers in Class-I only. The result is that graduate Engineers of long standing and good academic records who might have trained and reported upon the work of new entrants, end up as subordinates to those very officers in a few years. This creates anomalous and absurd situations besides encouraging jealousies and intrigue amongst members of Engineering Services. These jealousies have already taken deep roots in most of the departments and are undermining the foundation of the profession in Pakistan. Therefore steps must be taken to remove the source of evil to allow the Engineering profession to prosper and attract talent for betterment of Pakistan.

The strength of Class-I cadre in the Engineering department has always been much less than the actual requirements with the result, that most of the graduate Engineers to join the departments either as temporary Engineers or in Class-II. Their absorption in Class-I being dependent on the number of vacancies available. Even so, according to rules, a certain percentage of vacancies has to be filled by direct recruitment which generally eliminates the serving Engineers on account of age. Therefore there is a mad scramble in the Engineering departments for securing Class-I by fair or foul means. This also breeds contempt and jealousies amongst Engineers. If all the qualified Engineers were to be recruited at a common level, there would be no scope for leg pulling or supersessions. The Association demands that a reasonable level for qualified Engineers to start is Jr. Class-I level like the one granted to PCS, Medical graduates and Dentistry graduates. All initial recruitments (whether permanent or temporary) should be made at this grade counting seniority from date of entry subject to credit for higher qualifications.

The other serious problem gripping the Engineering profession is that of the diploma holders who cannot be ignored in the overall betterment of the profession. But it must be remembered that the efficiency of any technical profession is dependent on the skill and technical standard of its manpower. The diploma holders unfortunately lack basic education and are not adequately equipped to deal with planning, design or construction of projects. Even the maintenance works demand a good engineering background to be

able to diagnose the cause of defects before removing them at reasonable costs. It should be ideal to replace all the diploma holders with the Engineering graduates in all ranks.

The present conditions however demand a rational and human approach to deal with the existing majority of subordinates. The Association recognizes their grievance of being grossly underpaid as compared to other services. The recent decision of Government to start the ordinary graduates in Education Department at a grade of Rs. 300 to 325 P.M. has aggravated the situation especially when it is considered that the difference in the duration of study for a Bachelor's degree (in arts or science) and Engineering diploma is only one year which cannot possibly justify a difference of Rs. 125 in monthly pay between the two categories. This Association recommends that at least 10% posts of Overseers be created in a new grade called "Sub Asstt. Engineer" in the scale 350-25-750 so that officials do not stagnate and are able to make both ends meet after their retirement. This grade will provide incentive and remove frustration amongst Overseers who presently have to stagnate at Rs. 400 after 15 years' service. Once this is done, there will be no legal objection to the reversion of Overseers over and above their quota of 20% as they could be adjusted in the proposed grade without reducing their emoluments. As regards the posting of Sub Asstt. Engineers, they may be attached to the Divisional and Circle offices for estimation and survey work.

The Government should appoint a special commission to look into the production of diploma holders in the polytechnics keeping in view the actual requirements. The Association feels that the requirements of our times do not demand the production of undertrained and undereducated Engineers in the form of diploma holders especially on Civil Engineering side. This type of manpower is only useful for the under-developed countries where the aim is not to undertake large development works which situation Pakistan crossed about 16 years ago. We suggest that all polytechnics be attached with the Engineering Universities and the number of admission be reduced so that overall production of graduates from the existing colleges and polytechnics in West Pakistan does not exceed 1500 per year.

Merits and Precedents

The Engineers' demand for Class-I is not merely based on sentiments. It is very genuine one when it is considered that the best students from schools and colleges take up Engineering. The Engineering education is not only expensive but also very arduous with much longer courses of study than that of arts students. The Engineers' work in the field involves high financial responsibility besides being very difficult and hard. This is perhaps the only profession in the world that has not attracted women in large numbers which proves at least one thing that it is not an easy profession to practice. The Engineering degree is obtained after at least 6 years of Matriculation and is therefore equivalent to a Master's degree in Science or Arts subject. The Lecturers and the Headmasters have been given pay start equivalent to Class-I mainly on the strength of higher academic degrees which argument when applied to Engineering graduates merits their upgrading too. But the Engineers would insist on Class-I status as they have to work hand in hand with other public services and dessit being treated as inferior to any one.

We are passing through the age of Science and Technology and no advancement is possible if the practitioners of this profession are not given due status by administration. But unfortunately things are reverse; the technologists and Engineers in this country are on the lowest rung of the administration. The Government first upgraded PCS services as a whole from Class-II to Class-I. Then the Medical graduates were given Class-I and so were the Dentists. But unfortunately this favour has not been shown to the Graduate Engineers. The universal demand of all engineers in the country is that they should be treated at least at par with above-mentioned services, if not better.

It is sometimes argued that without the class system, the selection of talent is not possible. This is a fallacy because the talent also shows up in the professional examinations and is recognized by the Public Service Commission in selection. This is almost exactly what is done in the Central Superior Examinations and that is why no difference in pay and status is maintained between the candidate who stands first and that of the last man who may be inducted in the Superior Service. They are all classified as Class-I. On the same anology, the Engineering Graduates' demand that those of them who get inducted into Government service, which would automatically screen out mediocres owing to limited opportunities, be treated alike and placed in Class-I.

Financial Implications

The upgrading of Engineering service as a whole to Class-I can be accomplished in two stages. The existing graduates working as temporary Engineers or Class-II should be taken up in the first instance. In the second stage, the officiating SDOs in excess of prescribed limit of 20% should be reverted and replaced by graduates in Class-I grade. The financial implications of these two stages are discussed here:—

(*a*) Upgrading of existing graduates:

A summary of existing number of Engineers (both graduates and non-graduates) in the various departments for the whole of West Pakistan is given in Table-I. It will be seen that out of total 1770 Engineers in the three departments of Irrigation, B & R and Public Health Engineering, the number of Graduates comes to 1110 while the number of diploma holders comes to 660. Further break up of graduates reveals that 312 officers are in Class-I service while the balance of 798 Graduates are either in Class-II service or in temporary service. Of these 798 graduates, a large number (*i.e.* 329) is already officiating as Executive Engineers and as such no financial implication of any kind is involved in their elevation to Class-I. Of the balance of 469 (=798 - 329) officers, as many as 315 have already put in over three years of service and are drawing salary above the minimum of Jr. Class-I. Therefore, their upgradation involves but a marginal adjustment in the next higher step plus difference in technical pay. Assuming an average figure of Rs. 500 per year for this category, an annual expense of Rs. 1,57,500 will be required to upgrade these 315 officers. The remaining 154 graduate Engineers who have not yet completed 3 years' service will have to be placed at the initial grade of Jr. Class-I. Assuming that they all have completed one year's service, an additional expense of Rs. 90 P.M. will be required for each officer, that is to say an annual expenditure of Rs. 1,66,320. Therefore total additional expense of Rs. 3,23,820

TABLE 1.—*No. of Engineers in various departments*

S. No.	Category	Departments			
		I.B.	C&W	P.H.	Total
	GRADUATES				
1.	Graduates in Class-I	178	118	16	312
2.	Graduates in Class-II (offg. Xens).	166	28	9	203
3.	Graduates in Class-II (S.D.O.) ..	14	—	—	14
4.	Graduates as TAEs (offg. Xens) ..	25	70	31	126
5.	Graduates as T.A.E.	198	170	87	455
	Total (A) ..	581	386	143	1110
	NON-GRADUATES				
1.	N.G. in Class-I	—	1	—	1
2.	N.G. in Class-II (offg: Xens)	13	6	1	20
3.	N.G. in Class-II (S.D.O.)	20	39	—	59
4.	N.G. Offg: S.D.O.	373	164	43	580
	Total N.G. (B) ..	406	210	44	660
	Strength of Departments (A) + (B) = ..	987	596	187	1770
	Break-up of Graduate SDOs in terms of service				
1.	Class-II Graduates over 3 years ..	14	—	—	14
2.	T.A.E. Graduates over 3 years ..	147	102	52	301
3.	T.A.E. Graduates under 3 years ..	51	68	35	154
	Total : ..	212	170	87	469

Note:—The above officers include those on deputation.

(say 3,24,000) will be required in the first year.

In addition to above, the Government will be incurring a progressive increase due to difference in increment scale and technical pay. This works out to only Rs. 40 P.M. extra which when applied to 469 officers under discussion will mean an additional increase of about Rs. 2,25,000 every year over and above the figure of Rs. 3,24,000 in the foregoing para.

(*b*) **Replacement of officiating SDOs**

It will be seen from Table 2 that the number of officiating SDOs is much in excess of the quota of 20% fixed under the rules. In order to bring the number of diploma holders within the prescribed limit, reversion of 417 officiating SDOs will be involved. This reversion is likely to cause some administrative problems because in the process 417 Overseers will have to be retrenched. The Association suggests that the situation may be met

TABLE 2.—*Comparison of Graduate and Non-Graduate SDOs*

S. No.	Category	Departments			
		I.B.	C&W	P.H.	Total
1.	Graduates T.A.E.	198	170	87	455
2.	Graduates Class-II	14	—	—	14
3.	N.G. Class-II S.D.O.	20	39	—	59
4.	N.G. Offg: S.D.Os.	373	164	43	580
	Total (A) ..	605	373	130	1108
5.	Promotion quota for Overseers at 20% of (A)	121	75	26	222
6.	Actual No. N.G. S.D.O.	393	203	43	639
7.	Excess (6—5)	272	128	17	417
	Expenditure on replacing N.G. S.D.Os by graduate in Class-I at 6000 per year ..	16.32	7.68	1.02	25.02
	Additional/year due to increment etc. at 500 per annum	1.36	0.64	.09	2.09

in two ways. Firstly the officiating SDOs reverted to Overseer's grade should not be put to any financial loss and they should be allowed to draw the salary in the existing Class II grade which may be renamed as Sub Asstt. Engineer". The total number of such charges may be fixed at say 10% of the total number of Overseers in a department with minimum prescribed length of service as 12 years. These Sub Asstt. Engineers be posted in Divisional and Circle offices to help in estimation and survey etc. to relieve the Engineers for more creative work and better supervision. Fortunately, the total number of Circles and Divisions in the three departments nearly equals that of excess number of officiating SDOs and therefore it will be possible to accommodate most of the officiating SDOs reverted in the above manner. Once the excess number of officiating SDOs are reverted, it will be possible to absrob 417 fresh graduates. But since fresh graduates are proposed to be inducted at Class-I level, the Government will have to find finances to the extent of Rs. 25.02 lacs per year at the rate of Rs. 500 P.M. This expenditure and therefore reversions can be phased out in two or three years depending upon financial posion of various provinces.

The overall annual financial impact of upgrading existing graduates and that of replacing the excess number of officiating SDOs with graduates is given here department-wise:—

	I.B.	C&W	P.H.
Upgrading existing graduates:	3.40	2.89	1.47
Replacing the excess number of officiating SDOs.	16.32	7.68	1.02
Total (lacs):	19.72	10.57	2.49
Existing Budget (lacs):	70	55	14
% increase:	27%	19%	17%

Conclusions

The overall financial impact of granting Class-I status to graduates comes to Rs. 32.78 lacs against the total expenditure of Rs. 149 lacs which means an increase of only about 22%. This forms only a small percentage of development works being executed by these Engineering Departments. The Government is requested to take a bold decision keeping the overall interest of the Nation as a whole in view instead of being swayed away by other considerations. Sooner or later Government will have to accept that in this age of Science and Technology, the technologists must receive precedence over all other services and the sooner it is done, better it will be for Pakistan.

BOOK REVIEW

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— Construction Site Management
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— Building Regulations in North America
by D. E. Parsons, U.S.A. and Dr. R. F. Legget, Canada.

— After each chapter follows immediately an account of the discussions on the topic.

Proceedings of the 3rd Budapest Conference on Soil Mechanics and Foundation Engineering.

Edited by A-Kezdi, published by Akademiai Kiado, Publishing House of the Hungarian Academy of Sciences, Budapest. V. Alkotmany

U 21 Hungary, March, 1969. pages 685. Price 160$.

This conference which took place in October, 1968, contains 69 papers submitted from 16 countries and in four languages. There were three Topics.

1. The Physical Characteristics of Soils.
2. Bracing and dewatering of foundation Pits.
3. Design problems of deep foundations.

With these headings there is, of course, a great variety of Subject-matter.

The Proceedings of the Symposium, "The Management of Public Works Projects", held on April 15, 1960 at the University of Manchester, Institute of Science and Technology, are now available. The contents include:

* feasibility Studies, the justification for the project by Professor E. V. Morgan.
* Planning and Control—Mr. P. A. Thompson.
* Competitive and Selective Tendering—K. M. Wood.
* Road Works—Dr. I. C. Hilton.
* Government grants—Mr. J. Peeler.
* A new approach to organisation—Mr. C. Whyte.

Price 305, Institute of Science and Technology, P. O. Box No. 88 Sackville Street, Manchester 1. United Kingdom.

"Construction Estimates and Costs" by Harry E. Pulver, Consulting Engineer 4th revised Edition, 1969.

Published by McGraw-Hill Book Company, 330 West 42nd street, New York. 10036. Price $ 16.50.

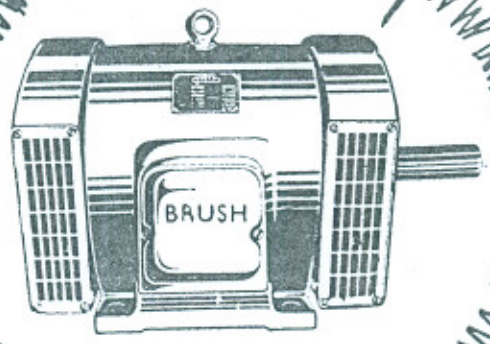
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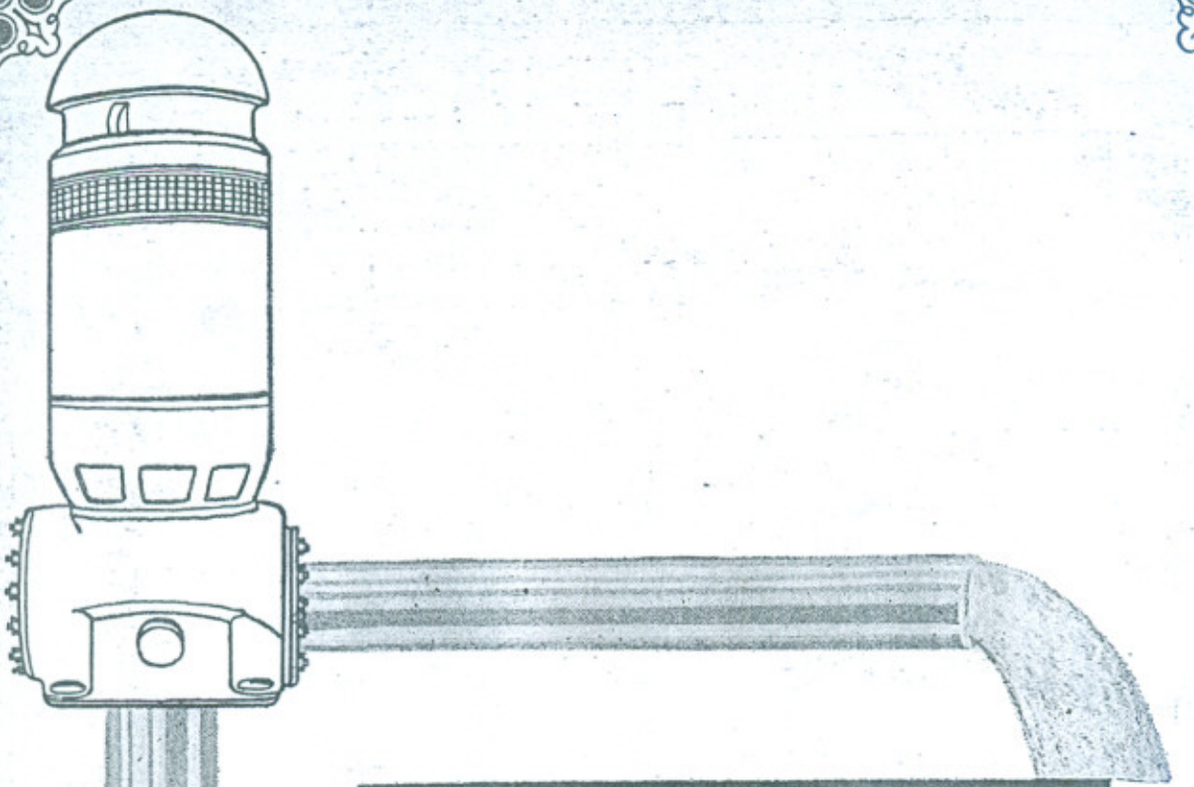
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