CEMENT RESEARCH INSTITUTE OF INDIA

CRI TECHNOLOGY DIGEST

STEEL FIBRE REINFORCED CONCRETE FOR AIRFIELD PAVEMENTS

December 1982

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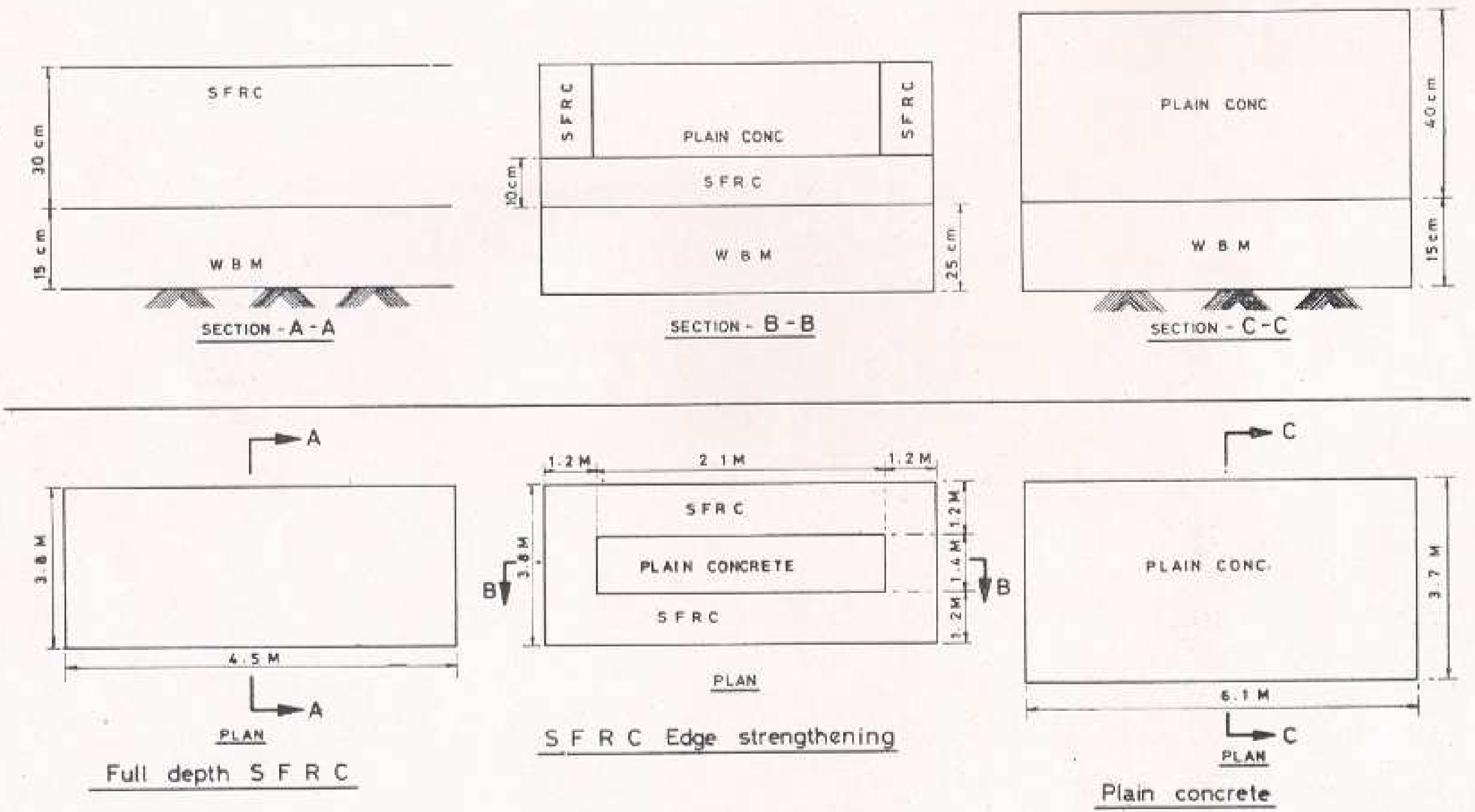
Following the development of technology for steel fibre reinforced concrete (SFRC), CRI had directed attention on applications of steel fibre reinforced concrete the first amongst these being its application to airfield pavements. Indeed, with the collaboration of the International Airports Authority of India (IAAI), CRI had laid two pavement slabs in a jet bay at Delhi Airport, as mentioned in an earlier Technology Digest (TD-11). The present Digest is solely devoted to CRI's work on application of SFRC for airfield pavements with special reference to mix details, process of making concrete, construction aspects and performance of the pavements.

SFRC IN PAVEMENT APPLICATIONS

SFRC is employed for runways and pavements mainly for: (1) New pavement slabs for runways, taxiways and jet bays; (2) Repair of damaged patches in existing runways, taxiways and pavement slabs; and (3) Overlays for repair of runways and taxiways, and for strengthening of existing runways and taxiways.

PERFORMANCE OF SFRC PAVEMENTS AND OVERLAYS

A large number of experimental pavement overlays and pavement slabs have been under observation for several years. Accordingly, the flexural strength of SFRC under field conditions in pavement applications has been found to be lower than that obtained in laboratory for corresponding mixes and seldom the 28-day flexural strength exceed 70-80 kg/cm^2. SFRC overlays often improved pavement life and provided better surface. Trials on SFRC pavements have shown that drying shrinkage, thermal expansion and thermal gradients are similar to those observed in plain concrete pavements. However, cracking of overlays is delayed by inclusion of steel fibre and the crack-width decreases with increase in fibre contents. SFRC has also been found to be very satisfactory as a repair material for pavements and runways.



(Not to scale)

Fig 1 Details of pavement slabs laid

CASE STUDY OF APPLICATION OF SFRC TO AIRFIELD PAVEMENT

To demonstrate the practical feasibility of SFRC for airfield pavements and for studying its long-term comparative performance *vis-a-vis* plain concrete, CRI laid one slab fully reinforced with steel fibres, the second provided with SFRC only in the zones where tension is likely to occur and a third of plain cement concrete (Fig 1). For designing the thickness of pavement, IAAI's multilayer method was used. The thickness of slabs where SFRC was used was three-fourth that of plain concrete (PCC) being used for the same area. To eliminate excessive stress and the consequent pavement deformation the base and sub-base were also strengthened.

LAYING OF JET BAY SLAB

To create additional parking bays it was decided to concrete the space available between the bays (green patches) and re-locate the parking position to give increased parking capacity. These green patches and parking bays are shown in Fig 2. It is one of these green patches where

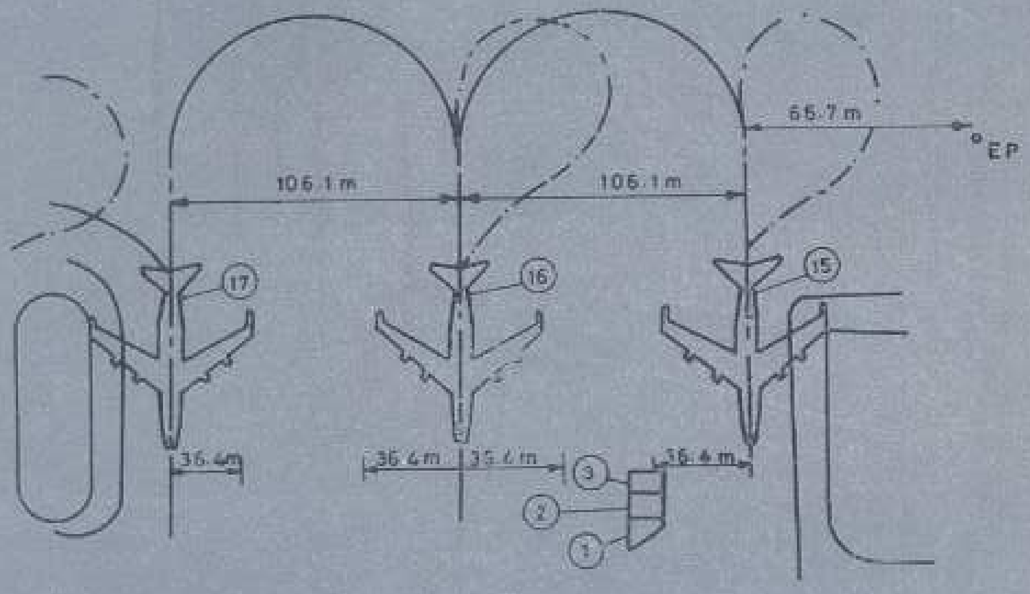


Fig 2 Location of the experimental pavements: 1 SFRC full depth; 2 SFRC edge strengthening; 3 PCC

three slabs of 4·5 m length and 3·8 m width were earmarked for laying three different combinations of plain and SFRC pavement system.

The production, transportation and placing of concrete is done manually in India, which poses many special problems while using SFRC. This issue was taken special care of in this project.

The concrete for conventional slabs was designed for a flexural strength of 38 ± 6 kg/sq cm. The aggregate used was of 40 mm and down size with continuous grading. The mix had a cement content of 330 kg/m^3 and a water-cement ratio of 0·48. For fibre reinforced concrete mix, a maximum aggregate size of 20 mm was chosen, the cement content was 410 kg/m^3 and water-cement ratio 0·65. 'Trough' shaped steel fibres were used in the mix to the extent of 106 kg/m^3 which is about 1·4% by volume. The diameter of the fibres used was 0·45 mm with an aspect ratio of 80. The proportioning of the SFRC mix was based on extensive tests carried out at CRI Laboratories.

Pan type concrete mixer of 350 litre capacity was used for mixing SFRC. A manually operated 'denester' was used to dispense the fibres into the concrete mixer. This provided a good fibre dispersion and homogeneous mix. Whilst the cement and fibres were weigh-batched, the aggregates were batched by calibrated boxes and the water by volume basis. The ingredients were first mixed dry till the fibres were thoroughly dispersed. Then the required quantity of water was fed into the mixer to get a workable mix. From the mixer, SFRC was carried in trollies to the final placement position. With the use of rakes the mix was evenly spread in layers. Suitable type of vibrators were used for the compaction of concrete. The concrete was laid in two layers (Fig 3) and extra concrete was levelled off using wooden plainers. The laid concrete was again compacted using screed vibrators. After the initial setting of concrete, the excess slurry was broomed off the surface to give parallel grooves for increased friction. The slabs were cured for 21 days by ponding water.

SURVEY OF CONDITION

The pavement has been in service since December 1980 and is used for parking of B-747, DC-10 and similar class of aircraft. No crack, spall, pitting or damage of any kind has been noticed in the SFRC slabs. Since this duration is too small to comment on the performance of any new material, a simulating test was therefore considered necessary.

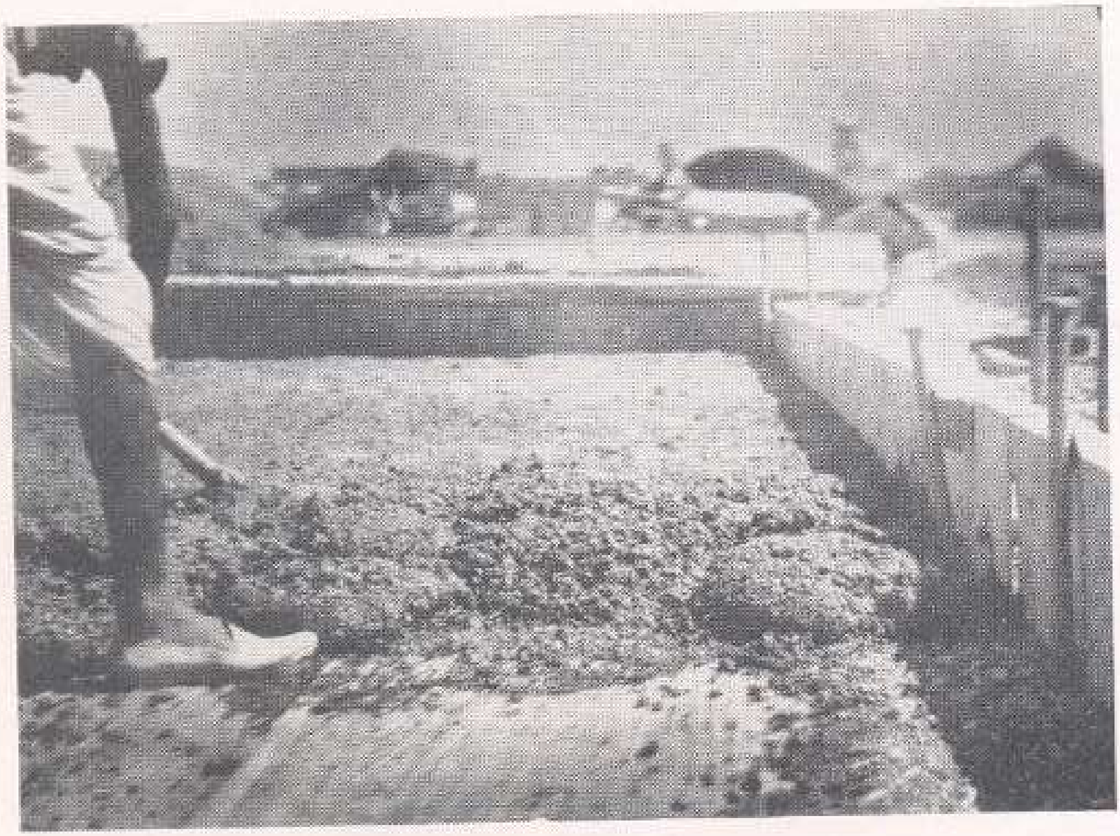


Fig 3   Compacting of SFRC with needle vibrator

The dynamic loading system (Fig 4) of IAAI was used to simulate aircraft loading and repetition on the pavement slabs. The equipment, when vibrated at the natural frequency of the pavement, generates a dynamic load of the order of 60-70 kips. Therefore, using the equipment, natural frequency of the three slabs was measured for loading at corner (critical conditions) position. The pavement was then loaded with the static load of the equipment over which a dynamic load of 6 kips was imposed. The frequency of load was kept equal to the natural frequency measured earlier. The slab was kept vibrating under this load till 'failure' is observed. The number of repetitions after which 'failure' is observed in the three slabs are as follows:

SFRC Slab	1,05,000
Plain concrete slab with SFRC edge strengthening	59,300
Plan concrete slab	43,500

It may be observed that SFRC slab, in spite of its reduced thickness, showed higher resistance under simulated dynamic testing.

CRI's CAPABILITY

The successful field application of SFRC for airfield pavement by CRI has made it the pioneer in this field in the country. Equipment-wise, pan type concrete mixer with dispenser attachments would be sufficient and conventional method of laying and compaction would do. It can be shown that by redesigning pavement thickness for higher flexural strength as obtained with SFRC, saving of cement is feasible *vis-a-vis* PCC pavements. In addition, in view of the improved fatigue characteristics of

Fig 4 Dynamic loading system

SFRC *vis-a-vis* PCC, the service life of SFRC pavements would also be much superior and longer.

CRI possesses the necessary technology and capability for dealing with SFRC in field on large scale concrete constructions. It is hoped that CRI's work on solving SFRC generate greater confidence in user organisations and help in many practical problems by appropriate utilization of SFRC in India.

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