

Superplasticized concrete Roads – A Case Study

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Till 1990, the roads in India have been built with inadequately thick flexible pavements topped with a thin bituminous course, and such construction demanded recurring maintenance and rehabilitation, which was not only uneconomical & but also not durable. The laying of these types of roads were very time consuming & labour intensive.

With the globalization & governments policy for investment in infrastructural projects like East West North South corridor, Golden Quadrilateral connecting all the four major metropolis, Airports, ports, Metros, there is going to be big leap in road networks. This has been made possible with the formation of National Highways Authority of India (NHAI) under Ministry of Surface Transport who has mandated to implement National Highways Development Project (NHDP) to undertake

- **India 's Largest ever highways project**
- **World class roads with uninterrupted traffic flow**

NHDP (Phase I & II) was launched in 1999 covering a length of nearly 14,000 km at an estimated cost of Rs. 54,000 crore and Phase III was launched in 2005 for upgradation and 4 laning of 10,000 km of selected high-density corridors of National Highways at an estimated cost of Rs. 55,000 crore. In addition, the NHDP has also been entrusted in implementing other projects on National Highways i.e. road connectivity to major ports in India.

NHAI is now responsible for implementing on National Highways of length around 24,000 Km. This has been made possible by changing over to modern concept of road construction.

In the past, the concept of concrete roads did not attract much attention from the authorities in India primarily because cement in India at that point of time was a scarce commodity. The major noteworthy road in concrete was taken up by Bombay Municipal Corporation for concreting major roads using ACC's cement. It was then a marketing plan to have a value addition.

The first major concrete highway (Agra-Mathura Road) was built back in 1960s, with some inputs from CRRI but the second one – a 60km, two-lane stretch of concrete road between Delhi and Mathura buildby IRCON in late nineties.

Towards the end of the Mumbai-Pune Expressway project, as part of the drive to improve the country's infrastructure facilities, the Government of India decided to implement the prestigious National Highway Development Project (NHDP), which initially involved four-laning and strengthening 13,146km of existing two-lane national highways. The project involved 5846km of the

Golden Quadrilateral connecting the four metros, and 7300km of the North-South-East-West corridor.

The National Highway Authority of India (NHAI), the implementing agency for the NHDP set up by the Government of India, decided to have over 1100km of the Golden Quadrilateral built using concrete slipform paving technology. They were encouraged by the success of the Mumbai-Pune expressway and the Indore bypass concrete road projects. The country's surplus cement production capacity and the spiralling cost of bitumen also helped the cause.

Concrete roads have a large number of advantages over bituminous ones. These advantages include:

- **Fuel Saving:** Concrete roads are rigid pavements, which do not deflect under load, unlike bitumen pavements. Hence load carriers require less energy when traveling on concrete roads (since no effort is expended in getting out of deflection 'ruts'). Trials carried out by the Central Road Research Institute, have shown that laden goods carriers consume 15-20% less fuel on concrete roads as compared to bituminous ones. Considering the fact that about 60% of our country's goods traffic moves by road, construction of a nation-wide network of concrete roads could thus save us hundreds of crores of rupees worth of foreign exchange now being spent on importing petroleum products.
- **Long Maintenance-Free Life:** Concrete roads have a life of 40 years or more, compared to 10 years for bituminous ones. In addition, concrete roads require almost no maintenance, whereas bituminous ones need frequent repairs due to damage by traffic, weather, etc.
- **Gain in Traffic Speed:** Concreting of existing roads in Mumbai, Nagpur, Calcutta and other cities has shown that this leads to significant gains in traffic speeds, making in turn for a notable reduction in congestion and jams on high traffic density roads. Increased traffic flow means saving of both time and fuel, as well as reduction of pollution caused by idling engines.
- **Resistance to Weather, Oil Spills, etc.:** Concrete roads are neither damaged by rain (being waterproof), nor softened and distorted by heat. They also do not lose their binder due to leakage of oil from vehicles. Hence they remain damage free under most adverse conditions.
- **Economy in use of materials:** For the same traffic load conditions, concrete pavements are thinner than bituminous ones. Where the load bearing capacity of the soil is poor, a bituminous pavements may have to be made more than one-and-a-half times thicker than a concrete one. Concrete roads thus use less aggregates, which are in short supply or difficult to procure in many places.
- **Environmental Friendliness:** Concrete roads are environmental friendly as compared to bituminous roads. Concrete production does not pollute the atmosphere like the hot-mix bitumen-based plants. Secondly, concrete for roads uses industrial wastes such as fly ash as the fifth ingredients. This addition makes the concrete durable, increases its density as well as its resistance to chemical attack.

However concrete roads are costlier to construct as compared to bituminous roads. None the less, with the price of bitumen going up steadily, and the use

of fly ash available free from power plants for adding it in making concrete mixes for pavements, the same is now being accepted. The relative cost of these two types of pavements could become quite comparable.

When life-cycle costs are considered (as recommended by the BIS, for all competing technologies), concrete pavements with their long life and negligible maintenance, come out invariably superior to bituminous ones.

With the increase in demand for roads & the setting up of NHDP, the cement industry with its increased capacity through Cement Manufacturers Association took up the issue with the government via various forums & seminars for adoption of cement concrete roads on National Highways. This also generated lots of interest among the engineering fraternity

Of late The National Highway Authority had identified an aggregate length of 1680 kilometer (two length equivalent) for adopting cement concrete pavement on Golden Quadrilateral under NHDP.

Buildtech Products India Ltd, an ISO 9000 certified company in the filed of construction chemical has contributed immensely in these projects in terms of developing & supplying admixtures for improving the workability & other properties concrete specially for RMC.

New generation Superplasticizers from Buildtech Products, BUILDPLAST SUPER HR was tested and extensively used for one such projects on a part of NH-1 in the state of Delhi.

The recent R&D in this field has generated substantial interest among the engineering fraternity & accordingly BIS has also made use of admixture complying to IS: 9103 as a mandatory requirement for mass concrete for superstructures.

This papers deals with various design aspect of concrete made with Buildplast Super HR for M15, M20 & M25 grade for culverts and other incidental structures on the highway.

The concrete to be used for this particular project has to be transported from a RMC plant situated some where in the middle of the total length. Therefore the foremost requirement of the concrete to be poured should have a suitable slump retention for placement as the total time required for its production at the batching plant & its pouring may be more than two hours that too at a temp of around 35°C.

It has been observed that in India where the concrete is done in daytime with a temperature goes beyond 40°C, the high loss of slump is not unusual. The selection of admixtures should be such that it can retain the slump for a considerable period of time without loosing its other behavior. Specially for road projects, Napthalene based superplasticizers has been found to be better in performance like retention of slump, superior finish & strength achievements. For this project, a specially blended superplasticizer based on Napthalene formaldehyde was used.

The tables & figures given are the final mix design obtained during numerous trials carried out at site using wide range of concrete materials.

MATERIALS

Low alkali content OPC Grade 43 conforming to IS: 8112 from JK cement was used for making both PCC & RCC. The fine sand & coarse aggregate was taken from Yamunanagar. The aggregates were tested as per IS: 383 for various properties required for designing the mixes. Apart from physical properties, the aggregates were subjected to alkali silica reaction studies & found to be innocuous. The sand conforms to zone II. The table 1 contains the details of testing of aggregates required for mix design.

Sr. No.	Particulars	Properties
1.	Specific Gravity	
i.	10mm	2.673
ii.	20mm	2.659
iii.	Fine Aggregate	2.683
2.	Water Absorption, %	
i.	Fine Aggregate	0.93
ii.	Coarse Aggregate	0.53
3.	Soundness Test	
i.	With Na ₂ SO ₄	0.49% < 12%
ii.	With MgSO ₄	3.0% < 18%
4.	Alkali Aggregate Test	Innocuous

Table 1 : Properties of coarse & fine aggregate

ADMIXTURES

To meet the requirement, high dosage of superplasticizers are used for M20 & M25 grade to achieve the desired consistency level. **Buildplast Super HR** – a new generation superplasticizers based on Napthalene Formaldehyde (SNF) from Buildtech Products I Pvt. Ltd, conforming IS : 9103 was used for designed mix & subsequently used extensively in the concrete for roads, culverts & ROB's. The chloride content & pH has been found to be within the prescribed norms of IS:9103. Since all these admixtures influences the physico mechanical behavior of cement, it is always desirable to check the compatible of the chemicals with the cement to be used for concreting. During various trials conducted at site, it was observed that the compatibility of Buildpalst Super HR has been excellent with JK cement.

MIX DESIGN

For culverts, ROB's and other structures, M 20 & M25 grade concrete was designed. Since the designated controlled concrete without admixture was difficult to pour or pump, the same was improved upon by incorporating superplasticizers and change in proportions of aggregates used in the design. The mix design used for both the grades is given in Table 2.

Sr. No.	Particulars	TRIAL I	TRIAL II	TIRAL III
1.	Grade of Concrete	M15	M20	M25
2.	Cement (kg)	310	330	370
3.	Fine Aggregate, kg	718 (73%)	699	670
4.	Coarse Aggregate, kg	1223	1243	1190
i.	10mm, kg	514 (42%)	559	535
ii.	20mm, kg	709kg (58%)	684	655
5.	Water, kg	155	148.5	166.5
6.	W/C ratio	0.5	0.45	0.45
7.	Admixture(dosage), kg Buildplast Super HR	1.86 (0.6%)	2.97 (0.9%)	3.70 (1.0%)

Table 2 : Mix Design adopted for various grade of concrete

The compressive strength tested at 28 days for all the three mixes have exceeded the target strength by almost 10%. The results are compiles in Table 3.

Sr. No.	Particulars	M15	M20	M25
1.	Air Temp °C	36	30	30
2.	Concrete Temp. °C	26	25	25
3.	Initial Slump, mm	130	120	150
4.	Slump after 45min, mm	70	70	90
5.	Compressive Strength,N/mm ²			
i.	7 days	21.5	19.7	23.5
ii.	28 days	29.8	33.4	39.3
6.	Target Strength	25	30	36

Table 3: Properties of fresh & hardened concrete

Mainly in cement concrete pavements or pavement quality concrete (PQC), the occurrence of shrinkage cracks during the green stage are quite prevalent. In this case, the cracks developed during the plastic stage was quite minimum however to reduce it further, following precautionary steps were taken.

1. Use of fly ash & blended cement (PPC) where fly ash was not available. This also reduces the alkali content & heat of hydration which indirectly responsible for the development of cracks in plastic stage.
2. Just after the laying, the surface was treated with BUILD CURE – pigmented curing membrane to protect the surface water from concrete to evaporate.
3. Brooming to be done at the plastic stage to make it uneven.



Fig 1 : Direct discharge of concrete

CONCLUSIONS

Mechanism of action of naphthalene modified superplasticizers on the fluidizing effect on cement concrete is clearly visible in the workability test and at the same time, the other properties like strength achievement at different ages have been more than satisfactory. It has also been observed that the quality of concrete produced in terms of bleeding, air entrainment or segregation improves substantially as compared to controlled concrete. These new generation chemicals appear to be in general more effective in terms of higher water reduction, low slump loss and lower retarding effect at very early stages. More recently these performances have been enhanced in view of some specific applications such as RMC transit mixers where slump maintenance behavior can be designed as a function of transport time and placing temperatures.

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