सत्यमेव जयते
MORTH
Government of India

WORKSHOP
ON
POPULARISING USE OF UHPFRC & FACTORY MANUFACTURED PRE-CAST CONCRETE ELEMENTS

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ULTRA-HIGH-PERFORMANCE FIBER-REINFORCED CONCRETE (UHPFRC)

- The UHPFRC matrix is generally composed of high amount of cement and silica fume as binder, steel fibers, very low Water/Binder (W/B) ratio and admixtures such as water reducer.

- UHPFRC has a very low water to cementitious materials ratio (0.18 to 0.25) and a dense particle packing, which leads to almost no shrinkage or creep, making it very suitable for concrete members under long-term loading.

- The presence of nano-additives improve the mechanical properties refines the pore structure, favors cement hydration, and improves durability. Moreover, in the cracked state, nano-constituents improve the self-healing capacity of concrete.

- The UHPFRC introduces significant enhancement in the sustainability of concrete structures due to its dense microstructure and damage-tolerance characteristics.

USE OF UHPFRC IN BRIDGES AND STRUCTURES

- As UHPFRC has a higher compressive, tensile and flexural strength, higher toughness and ductility compared to normal concrete, thus use of UHPFRC in structures is an effective strengthening technique for improving the strength, moment capacity, stiffness, and shear of RC columns under eccentric loading. It improves shear strength of RC Beam.

- UHPFRC also strengthens seismic deficient beam column joint in reinforced concrete structures.

USE OF UHPFRC IN BRIDGES AND STRUCTURES

Advantages

- Significant Cost Saving due to reduction in thickness of the concrete elements
- Reduction in life cycle costing due to less periodic maintenance
- Ensures high quality concrete by using specialized batching plant using separate silos for silica for steel fiber.
- Attains early strength which can help reuse of staging and shuttering faster in comparison to normal concrete
- Overall reduction in dead load of the structure
- Significant reduction in shrinkage cracks, particularly in deck slab which is otherwise common

USE OF UHPFRC IN BRIDGES AND STRUCTURES

Disadvantages

- No design parameters and methodology for UHPFRC are available in IRC Codes at this stage. If French design standards and material specifications are referred and used, then in that case the design needs to be finalized to be compatible with the environment, climate, materials, water quality availability at the project site at the DPR stage itself. This shall not be permitted as an alternative design at construction stage as this is likely to lead to undue delay in finalization of the design.

- Since production of UHBFRC requires sophisticated fully automated batching plant, use of such concrete will be viable only for Mega projects like extra dose / cable stayed / cantilever bridge or long viaducts having continuous spans or long spans.
- Reduction in thickness of concrete elements can create congestion of reinforcement and may lead to flow of concrete.

USE OF UHPFRC IN BRIDGES AND STRUCTURES

UHFRC in India

- Experience on Ultra-high-performance fiber-reinforced concrete in Indian condition is very limited. Moreover, codes and specifications are not available in IRC codes. Therefore, it may not be feasible at this stage to adopt this for small span structure with 30-50 m long considering viability economically. It can however be used for long span bridges like Extra Dose/Cable stayed bridge.

- Defect liability period of such bridges/structures should not be increased in the 'technology establishing stage' as the construction cost with UHPFRC is high, which includes stringent quality control during operation, and thus increasing the defect liability period may discourage the contractor to use UHPFRC .

USE OF UHPFRC IN BRIDGES AND STRUCTURES

UHFRC in India

As per MORTH circular, RW/NH-33049/01/2020-S&R (B) Pt.

- Recently UHPFRC girders have been used in Sole River Bridge at Km 42+050 of NH-752K near Latur (2X56 m span)

- A bridge over Ganga River parallel to JP Setu in Patna is under planning that envisages use of UHPFRC girders for 100 m span

USE OF UHPFRC IN BRIDGES AND STRUCTURES

Way Forward - UHFRC in India

- Development of guidelines and standards for design, construction, testing and long-term performance monitoring and evaluation (including seismic, wind-resistant, vessel collision, vehicle collision performances).

- Fundamental modelling for static and dynamic behaviours of bridge elements/components and connections, fabricated using UHPC materials.

- Design and construction method of prestressed UHPC girders developed for long-span bridges.

- Optimal performance and reliability based design methods involving bridge’s entire life-time cost considering design, construction, maintenance, and retrofit for the damaged components that may be caused by some extreme events, such as earthquake, hurricane, vessel collision etc.

USE OF UHPFRC IN BRIDGES AND STRUCTURES

Appications Around the World

- The first structural application of UHPFRC was the prestressed hybrid pedestrian bridge at Sherbrooke in Canada, constructed in 1997. The total span length of the bridge was 60 m, and the main span was assembled from six 10-m prefabricated match-cast segments.

- The Bourg-le`s-Valence bridge was the first UHPC road bridge in the world, built in France in 2001. The bridge was built from five assembled π-shaped precast UHPFRC beams, and the joints were made by in situ UHPFRC with internal reinforcements. The bridge consisted of two isolated spans with a length of approximately 20 m, and all the π-shaped beams were prestressed without transverse passive reinforcement.

USE OF UHPFRC IN BRIDGES AND STRUCTURES

Appications Around the World

- The Seonyu Footbridge, completed in 2002 in Seoul, Korea, is currently the longest footbridge made by UHPFRC (Ductal_) with a single span of 120 m and no central support.

USE OF UHPFRC IN BRIDGES AND STRUCTURES

Appications examples in bridge bearing components

Name	Country	Year	Application location
Mars Hill Bridge	United States	2006	I shaped beam [20]
Cat Point Creek Bridge	United States	2008	I shaped beam [21]
Jakway Park Bridge	United States	2008	PI shaped beam [22]
Sherbrooke Overpass	Canada	1997	Prestressed, post-tensioned space truss [23]
Glenmore Pedestrian Bridge	Canada	2007	Prestressed T-beam [24]
PS34 Bridge	France	2005	Box girder [25]
Pinel Bridge	France	2007	Prestressed T beam [26]
Pont du Diable Pedestrian Bridge	France	2008	U shaped beam [27]
Friedberg Bridge	Germany	2007	PI shaped beam [28]
Shepherds Gully Creek Bridge	Australia	2005	Precast, pretensioned I-beam [29]
WILD Bridge	Austria	2010	Arch rib [30]
GSE Bridge	Japan	2008	U shaped beam [31]
Papatoetoe footbridge	New Zealand	2005	PI shaped beam [32]
Peace Bridge	South Korea	2002	PI shaped beam [29]
Office Pedestrian Bridge	SouthKorea	2009	Cable-stayed bridge [33]
Kampung Linsum Bridge	Malaysia	2010	U shaped beam [34]
Celakovice Pedestrian Bridge	Czech Republic	2013	segmental deck [35]
Luan Bai trunk Railway Bridge	China	2006	T-beam [36]
Fuzhou University Landscape Bridge	China	2015	Arch rib [37]
Yuan Jiahe Bridge	China	2017	Πshaped beam [38]

USE OF UHPFRC IN BRIDGES AND STRUCTURES

Fig. 4. American Jakway Park Bridge. (Source: www.ductal.com).

Fig. 5. South Korea Peace Bridge. (Source: www.seoul.go.kr.com).

USE OF UHPFRC IN BRIDGES AND STRUCTURES

Appications examples in bridge deck Pavement

Name	Year	Position	Bridge type
Ma Fang Bridge	2011	Guangdong Province	Simple Box Girder
Buddha Chen Bridge	2014	Guangdong Province	Variable section continuous steel box girder [46]
Hai He Bridge	2015	Tianjin	Hybrid beam cable-stayed bridge [48]
Tong Hui Bridge	2015	Beijing	Deck beam arch combination bridge [48]
Dong Ting Lake Second Bridge	2015	Hunan Province	Plate-truss Composite suspension bridge [48]
Rong Jiang Bridge	2016	Guangdong Province	Hybrid beam cable-stayed bridge

Fig.11. Rong Jiang Bridge.

USE OF UHPFRC IN PAVEMENT

Advantages:

- The concrete hardening time is more as compared to asphalt. While an asphalt pavement can be trafficked as soon as the asphalt temperature has fallen down to a value close to the ambient one, it is necessary to wait for several weeks, before the traffic is allowed on concrete pavement. However, *high early strength* is a feature of all UHPFRC.

- In concrete pavement, the contact conditions with the base course i.e. curling of slab induces cracking in long run. These contacts conditions are controlled by the concrete shrinkage. In UHPFRC pavement, the drying shrinkage is generally low, as compared to ordinary concrete. Thus there is a reduction of drying-induced curvature which leads to longer life.

USE OF UHPFRC IN PAVEMENT

Disadvantages:

- At the production state, the preparation of this ‘high-tech concrete’ requires more constituents than ordinary mixes, as super plasticizer, silica fume or fibers. The local aggregate sometimes has to be substituted by another one of better quality. Therefore, new silos and additional production equipments may be needed. Also UHPFRC require systematically longer mixing duration than ordinary concretes. All this leads to high construction cost for UHPFRC

- The use of super plasticizer as a high-range water reducer leads to mixtures which display a higher plastic viscosity, for a given slump, this sometimes lead to difficulties in controlling the surface evenness of UHPFRC. Similarly due to low water-binder ratio, UHPFRC has high sensitivity to plastic shrinkage thus if curing is not done efficiently within a short time as required, there is every chances of wide cracking pattern appears which is very difficult to repair.

USE OF UHPFRC IN PAVEMENT

<u>Disadvantages</u>:

- Usual pavement concretes display quite stiff consistencies, owing to the laying technique (slipform machines, vibrating screeds…). The same tools applied to a fluid HPC sometimes lead to difficulties in controlling the surface evenness as shown below:

. Effect of excessive concrete fluidity and irregular machine speed on the evenness of a HPC thin slab [5].

Construction Methodology at present is not available for UHPFRC Pavement in IRC Codes

USE OF UHPFRC IN PAVEMENT

Way Forward for use of UHPFRC in Pavement:

➢ In UHPFRC tensile strength can be even doubled when going from normal to high-strength concrete. Thus the thickness of concrete slabs can be reduced, although the reduction is limited by the increase in E-modulus.

The construction cost of UHPFRC will come out to be higher than that of normal concrete pavement. Thus, considering the enhanced mechanical properties of UHPFRC, if by design the reduction in thickness in pavement is estimated that may compensate for that additional cost

Hence there is need to develop Design methodology for UHPFRC pavement for Indian Conditions.

THANK YOU !!!!!!