Concept of Self-Compacting Concrete

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Introduction :

NPCIL aims at producing power at reasonable rate without affecting flora and fauna. To meet the requirement of reasonable rate, the construction period has to be reduced, which in turn will reduce interest during construction. This will reduce capital cost and the unit cost will come down. To meet this goal, NPCIL adopts innovative techniques for speeding up construction. With this in mind, self-compacting concrete was developed and used at Kaiga Atomic Power Project Unit-3&4. This will enable to reduce construction time.

Why SCC ?

The Nuclear Power Plant structures are designed considering safety against radiation hazard. In view of this, the structures are required to be designed for higher seismic loads than conventional structures. Conventional structures are designed as per IS:1893 with appropriate importance factors. However, for designing nuclear power plant structures, site specific spectra is developed on the basis of past history of seismic events, the faults in the area by considering the same as active etc. In view of this seismic loading for which the structure is designed, becomes very high compared with loading considered for design of conventional structures. The percentage of steel goes up leading to congestion of reinforcement, particularly at column beam junction. When normal concrete is used for construction of these structural elements, number of construction joints are required to be increased to ensure proper placement and compaction. To Overcome this problem, self-compacting concrete was developed and successfully used at Kaiga Atomic Power Project Unit-3&4 and also developed and proposed to be used at Rajasthan Atomic Power Project Unit-3&4.

Definition :

Self-compacting concrete is the one, which is capable of getting compacted without any external efforts like vibration, floatation, poking etc.

Guiding principle :

The guiding principle for this type of concrete is that the sedimentation velocity of a particle is inversely proportional to the viscosity of the floating medium in which the particle exists.

Relation of SCC and Fly-ash :

The SCC needs large powder content. If the cement is used to meet the requirement of the powder content, it will lead to other problems arising out of high cement content. The economical option of meeting the requirement of higher powder content is to use fly-ash.

Ingredients :

The ingredients of SCC are same as those for the conventional concrete except that it is having high powder content and comparatively low coarse aggregate content. Additional ingredient is viscosity modified agent (VMA). VMA acts as a stabilizing agent and it also controls bleeding by changing the viscosity of the mix and influencing the shear resistance. This helps in keeping aggregate particles in floating state for a longer time and avoiding segregation.

Development :

The development of self-compacting concrete mix proportion was done as per EFNARC specifications and guidelines. These are the only guidelines available on the subject. No other codes, either national or international are available. The EFNARC guidelines give approximate method to be followed for mix proportion. It also gives the desired parameters in green state of concrete. Extensive trials were conducted at concrete testing laboratory of Kaiga Atomic Power Project-3&4. The selection of super-plasticizer and VMA is an important activity. Initially, SNF based admixture with diutan gum as VMA was tried. It was found to be difficult to control the setting time. In addition, the quantity of diutan gum required per cu. m. of concrete is very small (approx. 60 gm per cu. m.) and one can be always doubtful of proper dispersal of such a small quantity in 1 cu.m. batch of concrete. In view of this, poly-carboxylic ether based super-plasticizer with poly-acrylic based VMA was tried and found to be suitable. Following mix proportion was selected.

Grade	Cement (kg)	Flyash (kg)	Water (kg)	CA (kg)	FA (kg)	Superplasticizer/ (G) VMA (kg)
M.30	225	225	165	708	972	1.80/1.35

Similar efforts were done at Rajasthan Atomic Power Project unit-5&6 and following is the mix proportion selected.

Grade	Cement (kg)	Flyash (kg)	Water (kg)	CA (kg)	FA (kg)	Superplasticizer/ (G) VMA (kg)
M 25	225	225	180	624	988	4.27 /0.45

Mock ups:

After finalizing the mix, full scale mock-ups were conducted. Very congested column beam junction was selected for one mock up, thin wall element was selected for second mock up and L-beam was selected for third mock up.

It was observed during concreting and after removal of shutter that:

1. Concrete can be placed from 5.0 m height without segregation
2. Concrete can flow horizontally about 12.0 m without segregation
3. Concrete flows in highly congested area and fills the forms completely
4. The reinforcement gets completely encapsulated.
5. Finish is very good
6. No honeycombing observed.

Implementation of concept :

After successful mock ups, the concept of SCC was implemented in actual construction of safety related Pump House, Turbine Building, Control Building, tunnels etc.

Quality Control :

During actual construction, samples were cast, as a quality control measure. Following are the test results.

Parameters	KAIGA-3&4 *		RAPP-5&6 **	
	28 Day	56 Day	7 Day	28 Day
No. of Sample	51	23	6	6
Average Value (MPa)	40	49	20	35
Standard Deviation	4.5	3.8	0.49	0.25

* Field results
** Laboratory trial results

It can be seen that

- The strength results are consistent
- Standard deviation is very small, which indicates that the quality control is excellent.
- Strength gain from 28 day to 56 day is substantial.

Apprehension on concept of SCC

Major apprehensions are

- shutter removal period will get enhanced on account of use of fly ash
- Cost will be high

NPCIL's experience is contrary to the above mentioned apprehensions. Setting time was observed to be around 10 hrs. whereas, setting time of conventional concrete, at Kaiga, is around 9 hrs. Thus there is no appreciable change in setting time. It was possible to safely remove shutters for column after about 15 hrs. As regards to cost, it is true that shuttering needs strengthening as concrete remains in liquid stage for longer time, which exerts high liquid pressure at bottom of shutter. However, this cost gets compensated by elimination of efforts of vibration. Also possible defects due to over vibration or under vibration are eliminated thereby saving cost on repair / finishing. It can thus be seen that the cost of SCC is comparable with cost of conventional concrete.

Conclusion:

It can be concluded that

- The concept of SCC can be adopted on all the major projects for getting reduction in construction time and for getting enhanced quality and durability. SCC is more impermeable compared with conventional concrete. Typical RCPT value is around 1000 coulombs for SCC when compared with over 3500 coulombs for conventional concrete
- Concept of SCC is most suited for hydraulic structure where high level of impermeability is desired.
- SCC can be effectively placed in most congested areas and also where normal methods of vibration are not possible.