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Mix Design of Self-Defined (Self-compact -cum-Self-cured) Concrete using by Artificial Intelligence and its Performance under Indian Climatic Conditions

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Abstract—*Indian Construction industry follows the worldwide trends demanding new materials and innovative technologies. Cost effectiveness, long term predictable performance, structure aesthetical appearance, lack of experienced workers, environmental issues, improved health and safety are some of many issues. The construction industry is striving to find effective solutions for developments in cement and concrete science in recent years offer many new directions for material and application technologies. One of such directions is the reduction or even elimination of construction worker's input in executing concreting. This substantially improves the properties of cast in-situ concrete structures. High performance flow-able concretes and cementitious composites are developed to undertake the challenge. Development of such products and associated application technologies require substantial research and testing programmes. Despite the limited resources available for such research, India is keeping up with recent technology developments and is able to provide solutions to its demanding construction industry.*

At present concrete is widely used as construction material and it's improve day by day with the variation of their components and types of their use. After study of de-merits of widely used conventional concrete. The combination of self-compacting and self-curing concrete will be the perfect solution for all ignoring and de-merits of conventional concrete. Such value added construction material will be used in application and justifying the higher material and quality, control cost when considering the simplified placement and handling requirements of the concrete.

The Mix Design for concrete M35 grade is being done as per the Indian Standard Code IS: 10262-1982. On the basis of trail test method and the results point to the importance of selecting a well define combination of component of materials for respectable performance of Self-Defined (Self-Compact-cum-Self-Cured) concrete under Indian Climatic Conditions.

1. INSTRUCTION

Self-compacting concrete is one of the most developed concrete and almost used in all over world with incomparable benefits in workability, reductions of labour costs, perfect finished surface, soundless and higher strength properties compared to conventional concrete. Self-curing concrete (Internal curing) is also extensively used to reduce the autogenously shrinkage and consequently mitigate the high risk of early age cracking and strength of concrete compared to conventional concrete (surface curing concrete). The material components of the both concretes are widely present in market as supplementary cementing materials.

After study of de-merits and deficiencies of widely used conventional concrete. The combination of self-compacting and self-curing concrete will be the perfect solution for all ignoring and de-merits of conventional concrete. Such value added construction material will be used in application and justifying the higher material and quality, control cost when considering the simplified placement and handling requirements of the concrete.

The aim to evaluate the ability of the design mix of the self-defined concrete prepare with two admixtures viscocrete 10 H-1 as self-compacting agent and polyvinyl alcohol as self-curing agent in flowability, viscosity, water retention and compressive strength. The selected admixtures performing very effectively in individual type of concretes. Now they are together, so it's very important to analyze how they perform in composed form. The benefit of the self-defined concrete is more significant in confined area, in high temperature area's and in desert where water is not adequately available as well as the shortage of skilled workforce. In this study the Mix Design for concrete M35 grade is being done as per the Indian Standard Code IS: 10262-1982. On the basis of trail test method and the results point to the importance of selecting a well define combination of component of materials for respectable performance of Self-Defined (Self-Compact-cum-Self-Cured) concrete under Indian Climatic Conditions. The compressive strength, workability results are brief the performance and ability of concrete. The important parameters

are admixtures Viscocrete 10 H-1 and Polyvinyl Alcohol and the basic constituents cement and W/c ratio.

2. EXPERIMENTAL WORK

2.1 Concrete mix and Materials

The main constituent's variable parameters in this study were cement, flyash, silica fume and w/c ratio. Table 1 & 2 gives the details about the mixes which are used at first & second level.On the behalf of first level test results prepare the final level concrete mix with the addition of two admixtures Viscocrete 10 H-1 and Polyvinyl Alcohol, table 3 gives the details about quantities of admixtures add in the final mix of concrete. A total seven numbers of mixes were used with different variables of all four main constituents. For evaluating the compressive strength two curing regimes are used for self-compacting concrete mixes without self-curing agent; continuously water cured and air cured. At final level the self-curing agent is used with different values in two mix of concrete, in which the self-compacting agent also used accordingly and evaluate the compressive strength only single regime i.e. Air cured

Table 1: Predicted compressive strength by a model and percentage error as compared to actual compressive strength

Mix No.	Testing Inputs				Compressive Strength N/mm² (Mpa)		% Error
	Cement (kg/m³)	Flyash (kg/m³)	Silica Fume (kg/m³)	Water (kg/m³)	Target Strength / Predicted	ANFIS Output/ actual Strength	
1	409.28	48.15	24.07	178.15	43.25	42.3	-1.02246
2	409.28	48.15	48.15	182.97	42.8	41.63	-1.0281
3	409.28	48.15	24.07	182.97	43	39.29	-1.09443
4	385.2	72.22	24.07	182.97	42.5	40.8	-1.04167
5	385.2	24.07	72.22	192.6	42.5	43.39	0.979488
6	385.2	24.07	72.22	182.97	43.5	44.13	0.985724
7	433.35	24.07	24.07	172.14	43.5	42.3	-1.02837
Average Error							-3.24981

Cementations materials

Ordinary Portland Cement (OPC) 43 grade with 3.22 specific gravity is used in all test specimens. Flyash with 2.07 specific gravity and silica fume [CICO MS] are used as a replacement of the cement content by different percentage to reduce the dosage of chemical admixtures needed to obtain the required slump flow and viscosity.

Aggregates

Cursed coarse aggregate used in two different nominal size 10 mm and 20 mm with proportion percentage ratio (55:45) and the aggregates tests carried out as per IS: 383:1970.

Chemical admixtures

The two admixtures are used in this study, Visocrete 10 H-1 is used to suitable extended workability, very high water reduction up to 30 percent and excellent flow characteristics. The dosage of Viscocrete was 2 to 2.5 % of the water volume. Polyvinyl Alcohol is used to maintaining the satisfactory moisture content in concrete during its early stage strength

Table 2: Second Level Concrete Mix for evaluate the harden property of concrete on site / field test

Mix No.	Cement (kg/m³)	Flyash (kg/m³)	Silica Fume (kg/m³)	Water (kg/m³)	Fine aggregate (kg/m³)	20mm Coarse aggregate (kg/m³)	10mm Coarse aggregate (kg/m³)	Admixture/ Superplasticizer (litres).
1	409.28	48.15	24.07	178.15	1000.24	366.75	300.07	3.56 (2%)
2	409.28	48.15	48.15	182.97	1000.24	366.75	300.07	3.66 (2%)
5	385.2	24.07	72.22	192.6	1000.24	366.75	300.07	3.85 (2%)
6	385.2	24.07	72.22	182.97	1000.24	366.75	300.07	3.66 (2%)
7	433.35	24.07	24.07	172.14	1000.24	366.75	300.07	3.44 (2%)

Table 3: Final Mix Proportion of Self Defined Concrete

Mix No.	Cement kg/m³	Flyash kg/m³	Silica Fume kg/m³	Water kg/m³	Fine aggregate (kg/m³)	20mm Coarse aggregate (kg/m³)	10mm Coarse aggregate (kg/m³)	Visco-crete 10 H-1 (Litres.)	Polyvinyl Alcohol Cold (kg)
5a	385.2	24.07	72.22	192.6	1000.24	366.75	300.07	3.85	1.926
5b	385.2	24.07	72.22	192.6	1000.24	366.75	300.07	4.82	2.889

development [in order to develop the desired properties and stop the weight loss and water evaporation]

Specimens and Testing

The ANFIS MODEL is designed by loading data, generating fuzzy inference system (FIS) and training FIS. The input parameters were cement, Flyash, silica fume and water content in kg/m^3. The Output parameter was standard 28-days cube strength in Mpa. The data set having these four inputs and one target or output for 29 mixes presented is used for designing model and data set for remaining 7 mixes is used to check accuracy of prediction (Table 1).

The results of compressive strength predicted by the model when compared with experimental results found average error

of - 3.24981 % only (Table 1). The mix 1,2,5,6 & 7 are select for testing at site physically to the actual behavior and strength of the mix sample. At this second stage the Viscocrete only add in the selected mixes of concrete and evaluate under two regimes water cured and air cured. According the field results final level mix prepare & evaluate the hardened properties of designed concrete under air cured regime, because at this level self-curing agent Polyvinyl Alcohol is used, Table 3 give the final mix details.

ANFIS Model is used to test and compare the compressive strength with predicated compressive strength. The workability slump flow T50, L-box, V-funnel with T5 minutes are conduct on site to evaluate the self-compacting concrete abilities at second level, Table 4 show the standard parameter of conduct test. In slump test, the cone is filled with concrete and then lifted vertically and the time measurement is started as shown in fig. 1. The spread diameter T_{50} (i.e. the time of flow to reach a diameter of 500mm) and the general visual appearance of the concrete are recorded. L-Box test is used the passing ability of concrete in between the bars as shown in fig.2. If the concrete flows as freely as water, at the rest it will be horizontal, so H2/H1=1.Therefore the nearer this test value, the "blocking ratio" is to unity, the better the flow of concrete. V-funnel test is used to evaluate the viscosity of self-compacting concrete, the test is carried out by filling a funnel with about 12 l of concrete and then measured time in seconds that the concrete takes to drain of the funnel as shown in fig.3, the results obtained from these tests indicated that, mixes had good filling and passing ability as well as segregation resistance, the time recorded for 500 mm diameter of concrete, the final concrete diameter and the time V-funnel & L-box increased with increase in the percentage of fly ash and silica fume [17]. The hardened concrete property compressive strength only tested at 3days, 7days and 28 days interval in the final level. The cube testing as shown in fig.4

Fig. 1: Slump test apparatus and Test reading

Fig. 2: L-Box test apparatus and Test reading

Fig. 3: V-Funnel Test Performing.

Fig. 4: Cube Test is in Progress for Compressive Strength

Table 4: Standard Parameters of Tests

Method	Property	Standard value
Slump flow	Filling ability	(650-800) mm
V-funnel at T5 minutes	Segregation resistance	(8-12) second
L-Box	Passing ability	(0.8-1.0)

Test results and discussion

Obtained the test results for workability slump flow, L-box and V-funnel according to the different used constituents for all five mixes are shown in table 5.

Table 5: Workability test values

Mix No.	Slump flow(mm)	V-funnel (sec)	L-Box (h_2/h_1)
1	580	11.30	0.82
2	655	10	0.85
5	710	8.3	0.90
6	700	9.4	0.88
7	640	10.2	0.83

Compressive strength results of designed concrete in all three level according to different constituents and admixtures are shown in fig.5. The harden property of concrete in two different regimes water cured and air cured at 3 days, 7 days and 28 days are shown in fig.6 and water cured compressive strength at all three intervals are shown in fig.7. The final level workability slump flow, L-Box and V-funnel test results are shown in table 6 and the air cured concrete compressive strength.

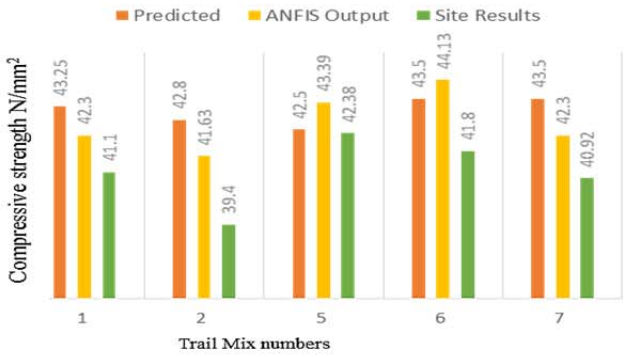

Fig.5 Comparison Chart of compressive strength Predicted V/s ANFIS Output V/s Site results

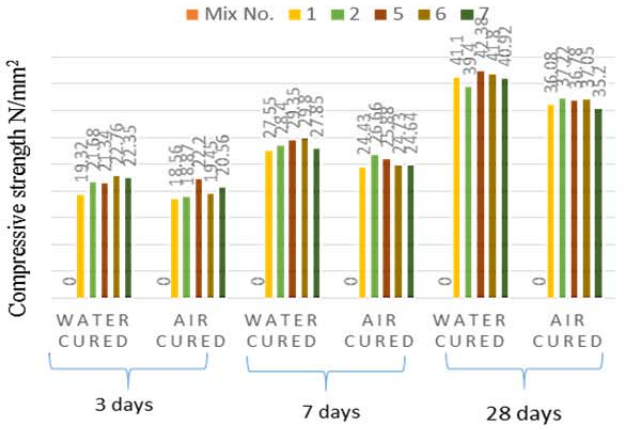

Fig.6 Compressive Strength (N/mm²) of sample water cured and air cured

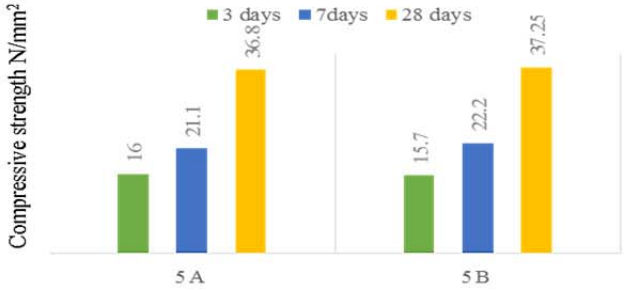

Fig.7 Compressive strength Chart of Self-Defined concrete samples at 3,7 and 28days

Table 6: Self- Defined Workability test values

Mix No.	Slump flow(mm)	V-funnel (sec)	L-Box (h_2/h_1)
5A	725	8.76	0.92
5B	740	8.45	0.92

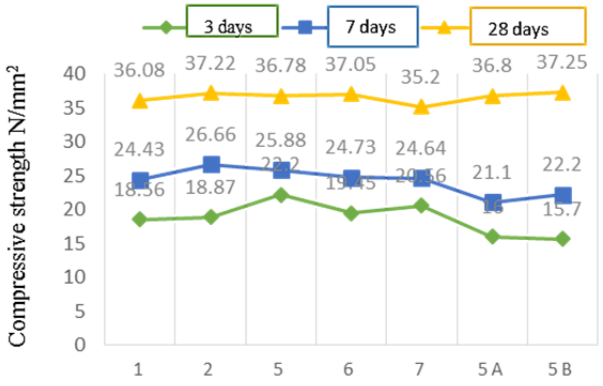

Fig.7 Comparsion of Compressive strength Chart of Self-compact & Self-Defined concrete samples at 3,7 and 28days

3. CONCLUSIONS

The Performance of designed concrete on the base their trail mix and the percentage of admixtures dosage and ANFIS model based results compression with actual site practical results. Observation of performance based on the obtained results as following:

- ANFIS Model working and its results are appreciable for calculating the compressive strength. The system was good for measuring the results according the training data. Only one drawback in the system, it was totally worked on training data, if we are selecting the wrong data, then it will be misguide us.
- Self-defined concrete at the stage of self-compacting performance was satisfactory with 10% FA and 5% SF with 0.37% W/C ratio at 28days under water cured condition. The percentage of FA and SF was equal 10% the result was not good as compare the first one.
- 5% FA and 15% SF with 0.40% W/C ratio performance was very good all of them. At 3 days air-cured compressive strength result is better than water cured. At 7 & 28 days overall result was good and achieves the highest value of compressive strength at 28 days in all trail mix samples.
- □□The Slump value also good with 15% of Silica Fume SF, its fineness worked and help to improve the flowing capacity of concrete with W/C ratio 0.4% and viscocrete 2%.
- Self-Defined concrete performance and results are satisfactory with 1% and 1.5% of Polyvinyl Alcohol PVA cold. After the successful result of mix no-5, we are selecting this mix for self-defined concrete with the addition of PVA cold and its worked and showing satisfactory results. 1.5% PVA results slightly lower than

1% of PVA at 3 days compressive strength. It means the early age strength affected with increase the PVA percentage. Overall results of 7 and 28 days are satisfactory with higher percentage of PVA.

- PVA Cold slightly increased the slump value of fresh concrete, its mean it help to improve the flowing capacity and viscosity of concrete with generating the thin film surrounding the aggregates.

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