DETERMINATION OF OPTIMUM DOSAGE OF SAP FOR SELF COMPACTING TO SELF CURING CONCRETE

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ABSTRACT

Concrete occupies unique position among the modern construction materials, Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as a aggregate (usually made for different types of sand and gravel), that is bond by cement and water. Self – compacting concrete (SCC) is a high – performance concrete that can flow under its own weight to completely fill the form work and self-consolidates without any mechanical vibration. Such concrete an accelerate the placement, reduce the labour requirements needed for consolidation, finishing and eliminate environmental pollution. The so-called first-generation SCC is used mainly for repair application and for casting concrete in restricted areas, including sections that present limited access to vibrate. Such value-added construction material has been used in applications justifying the higher material and quality control cost when considering the simplified placement and handling requirements of the concrete. The successful production of self – compacting concrete (SCC) for use, is depended on arriving at an appropriate balance between the yield stress and the viscosity of the paste. Specially formulated high range water reducers are used to reduce the yield stress to point to allow the designed free flowing characteristics of the concrete. However, this alone may result in seggregation if the viscosity of the paste is not sufficient to support the aggregate particles in suspension. However, for self compacting concrete surplus amount of water is needed for curing. To reduce the amount of water required for curing, self curing concrete is prefered. In self curing concrete internal curing is done. For making of the self curing concrete certian admixtures is to be added. Here, we use Super Absorbent Polymer(SAP) as admixture and determined its optimum dosage.

I. INTRODUCTION

Concrete is having a vital role in construction industry. Concrete is a mix of cement, fine aggregate, coarse aggregate and water. Concrete is the most widely used construction material in the world. The concrete should be compacted or vibrated properly to attain full strength. But the manual and mechanical operation cannot do better compaction. Recognizing the lack of uniformity and complete compaction of concrete by vibration researchers developed a concrete which does not require vibration to achieve full compaction. It is named as the Self-compacting concrete or self-consolidating concrete. A self consolidating must have a fluidity that allows self – consolidation without external energy, remain homogenous in a form during and after the placing process and flow easily through reinforcement. In rheological terms, even though a significant amount of research tends to show that SCC's viscosity varies with the shear rate and acts as a pseudo plastic material, SCC is often described as Bingham fluid (visco elastic) where the stress/shear rate ratio is linear and characterized by two constants – viscosity and yield stress. Back to the performance based definition of SCC, the self – consolidation is mainly governed by yield stress, while the viscosity will affect the homogeneity and the ability to flow through reinforcement. As the SCC viscosity can be adjusted depending on the application, the yield stress remains significantly lower than other types of concrete in order to achieve self – consolidation.

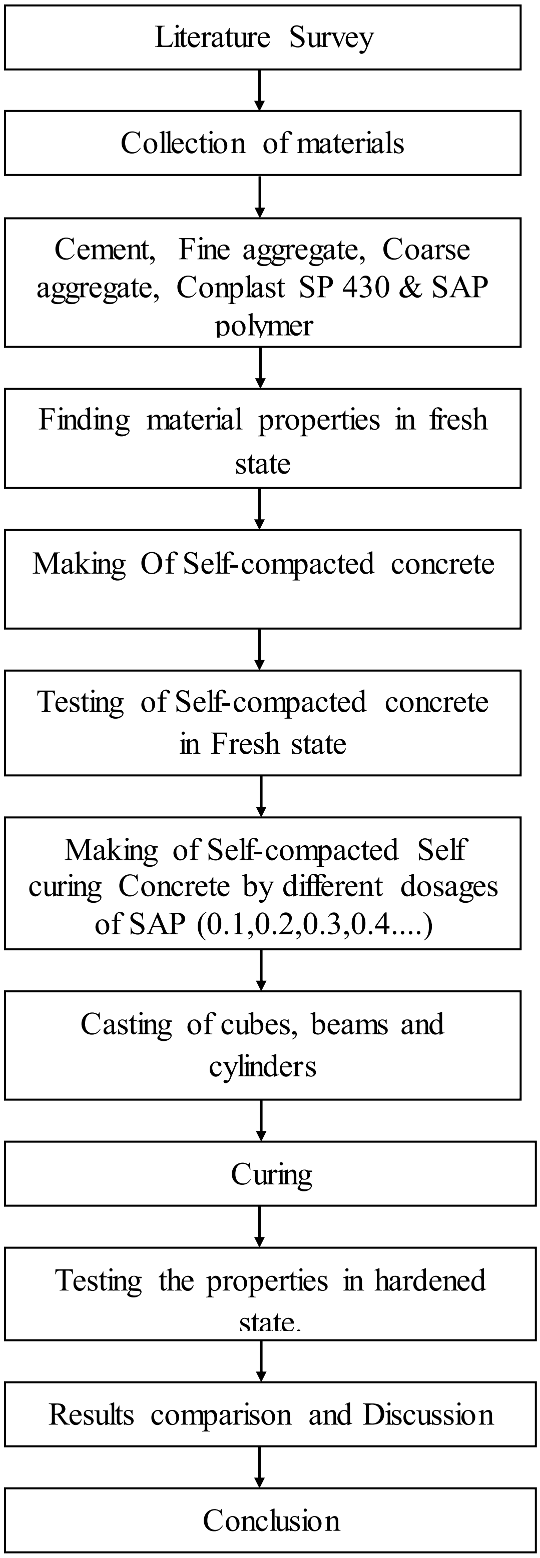
II. OBJECTIVE AND SCOPE

This concrete having self-compact ability with which it can be placed in the every corner of formwork without vibration causing no segregation. The performance evaluation method of fresh Self-Compacting Concrete widely differs depending on whether vibration is given to the concrete during placing. For this reason, the scope is limited to Self-Compacting Concrete that can be placed without any external forces other than gravity. Self-Compacting Concrete not only increases the reliability of structures but also reduces the number of workers required at the construction site and streamlines the construction. In precast product plants as well, Self-Compacting Concrete is highly effective in reducing the noise as it requires no vibration.

- To have an idea about making procedure of self-compacted self-cured concrete.

- To find the two key fresh properties of SCC – filling ability and passing ability - for mix design purposes in the lab.
- A range of results for the chosen tests to identify suitable SCC.
- The Guidelines of standards for the test methods are verified.
- The hardened concrete property of self-compacting self-cured concrete with SAP (Super Absorbent Polymer) is studied.

III. METHODOLOGY



This section briefly explains the methodology adopted in this. The following methodology has been adopted to achieve above objective. In the first phase, physical, chemical and mechanical properties of all ingredient of concrete were found out. In the second phase, initially compressive strength of cubes and cylinders, split tensile strength were found out. Finally beams were subjected under two-point loading to study the flexural behaviour and other salient features of concrete beams. The experimental investigation is conducted as detailed below. All the materials tests were conducted in the laboratory as per relevant Indian Standard codes. Basic tests were conducted on fine aggregate, coarse aggregate, and cement to check their suitability for concrete making. The properties of fine and coarse aggregates, sieve analysis of fine and coarse aggregates, tests on cement are to be found. The study aims to investigate the strength related properties of concrete of M_{30} grade with self compacting concrete. The proportions of ingredients of the control concrete of grade M_{30} had to be determined by mix design with reference of Okamura and EFNARC. The cubes are cast as per the M_{30} grade of concrete. These are tested in the lab to find the hardened properties and to make a conclusion which one is best.

IV. EXPERIMENTAL INVESTIGATION

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining with the object of producing concrete of certain minimum strength and durability as economically as possible.

1. Gibbs (1999) states that the following particle riles of thumb for the proportioning of SCC mixture exist.

2. Okamura and Ozawa (1995) have proposed a simple proportioning system assuming general supply from ready-mixed concrete plants.

3. The “Standardized mix design method of SSC” proposed by the JRMCA (1998) is a simplified version of Okamura’s method. This method can be employed to produce SCC with a large amount of powder materials, and water-binder ratio of less than 0.30.

4. In designing the mix it is most useful to consider the relative proportions of the key components by volume rather than by mass.

Generally, it is advisable to design conservatively to ensure that the concrete is capable of maintaining its specific fresh properties despite anticipated variations in raw material quality. Some variation in aggregate moisture content should also be expected and allowed for at mix design stage. Normally viscosity-modifying admixtures are a useful tool for compensating for the fluctuations due to any variations of the sand grading and the moisture content of the aggregates.

Mix design forM_{30} grade concrete according to BIS method.

Design stipulations

1. Characteristic compressive strength required in the field at 28-days : 30Mpa

2. Maximum size of aggregate : 12.5mm (rounded)

3. Degree of workability : 0.9(compaction factor)

4. Degree of quality control : Good

5. Type of exposure : Severe

Test data of materials

1. Specific gravity of cement : 3.01

2. Compressive strength of cement at 7-days : Satisfies the requirements of IS269- 1989(37N/mm2)

3. Specific gravities of Coarse aggregate : 2.625

Fine aggregate : 2.613

4. Water absorption

Coarse aggregate : 0.5%

Fine aggregate : 1.0%

5. Free surface moisture

Coarse aggregate : NIL

Fine aggregate : 2.0%

6. Fineness modulus of

Coarse aggregate : 6.15

Fine aggregate : 2.72

Steps taken in the mix proportioning

1. Target mean strength for M_{30} grade concrete

fck* = fck +Ks

fck* = 30+1.65*6.0= 39.9N/mm2

Where,

K = 1.65 from table 10.4 of IS code of mix design 10262 :1982

S = 6.0 from table 10.6of IS code of mix design 10262 :1982

2. The water cement ratio required for the target mean strength of 39.9 Mpa is 0.38.

3. Selection of water and sand content for 12.5mm maximum size aggregate and the sand confirming to ZONE - II.

For W/C-0.6, C.F-0.8,angular,sand confirming to ZONE-II.

(a). Water content per cubic meter of concrete = 208.l/m3

(b). Sand content as percentage of total aggregate by absolute volume = 62%

(c). C.F. = 0.9

Corrections

Change in condition	Water	Sand
W/C(0.6-0.38 = 0.22)	0	-4.4%
C.F = 0.1	+3%	0
Rounded	-15kg	-7%
Zone -2	0	0

The corrected water content per cubic meter of concrete

208 + ((3/100)*208) -15 = 199.24 l/m3

The corrected sand content as percentage of total aggregate by absolute volume

62 % - 11.4% = 50.6%

4. Determination of cement content Water/cement = 0.38

Water = 199.24 l/m3

The cement content = 199.24kg/m3

5. Determination of coarse and fine aggregate contents for the specified maximum aggregate size of 12.5 mm, the amount of entrapped air in the wet concrete is 3%, taking this in to account and applying equations

$V= [W+C/S_C+ f_a/ (P*S_{fa})]*1/1000;$

$V= [W+C/S_C+C_a/ ((1-p)*S_{ca})]*1/1000;$

0.97= [199.24+ (524.31/3.01) + fa/ (0.506*2.613)]* 1/1000.

Fa=788.77kg/m^3

0.97= [199.24+ (524.31/3.01) +Ca/ ((1-0.506)*2.625)]*1/1000.

Ca=773.06kg/m^3.

The mix proportion then becomes

Cement	Sand	Coarse aggregate	Water
524.31 kg	788.77 kg	773.06 kg	199.24
1	1.5	1.47	0.38

The obtained contents of cement, sand, aggregate and water per cubic meter of concrete are listed below.

Cement = 524.31kg

Sand = 788.77kg

Coarse aggregate = 773.06kg

Water = 199.24kg

Converting into SCC Proportions. The normal concrete mix proportions are modified as per EFNARC specifications and different trail mixes and caste. By considering the fresh properties and harden properties of the mixes we finally arrived at the SCC mixed proportions as

Cement = 524.31

Fine aggregate = 788.77

Coarse aggregate = 773.06

Total aggregate (T.A) = 788.77+773.06 = 1561.83

Taking 56% of T.A as F.A

F.A= 1561.830* 0.56 = 874.62 kg/m^3

C.A =687.2kg/m^3

The modified proportion is

Cement	Sand	Coarse aggregate	Water
524.31 kg	874.62 kg	687.2 kg	199.24
1	1.67	1.31	0.38

Table I Mix Proportion

CEMENT	**524.3 Kg**
FINE AGGREGATE	**874.62 Kg**
COARSE AGGREGATE	**687.2 Kg**
WATER	**199.24 Litre**
CONPLAST SP430	**0.5 litre/ 100 Kg Cement**
SAP	**0.1,0.2,0.3 & 0.4 etc weight of cement**

TEST ON FRESH STATE

TEST PROCEDURE ON FRESH SCC

Tests on fresh concrete were performed to study the workability of SCC with various proportions of rock dust and silica fume. The tests conducted are listed below:

- Slump flow test
- V- funnel flow test
- U-box test
- L-box test

Table II Acceptance Criteria for SCC

Sl. No.	Test Conducted	Unit	Typical range of values	
			Minimum	Maximum
1	Slump-flow	Mm	650	800
2	V-funnel	Sec	6	12
3	L-Box	(h_2/h_1)	0.8	1.0
4	U-Box	$(h_1\text{-}h_2)$	0	30

Table III Test results in fresh state

Sl. No.	Test Conducted	Unit	RESULT
1	Slump-flow	Mm	676
2	V-funnel	Sec	10
3	L-Box	(h_2/h_1)	0.94
4	U-Box	$(h_1\text{-}h_2)$	7

TESTS ON HARDENED STATE

COMPRESSIVE STRENGTH OF CONCRETE

Compressive strength of concrete is defined as the load, which causes the failure of a standard specimen.(Ex 100 mm cube according to ISI)divided by the area of cross-section in uniaxial compression under a given rate of loading. The test of compressive strength should be made on 150mm size cubes.

Place the cube in the compression-testing machine. The green button is pressed to start the electric motor. When the load is applied gradually, the piston is lifted up along with the lower plate and thus the specimen application of the load should be 300 KN per minute and can be controlled by load rate control knob. Ultimate load is noted for each specimen. The release valve is operated and the piston is allowed to go down. The values are tabulated and calculations are done.

$$\boldsymbol{Compressive\ strength = \frac{Compressive\ load}{Surface\ area}}$$

V. RESULTS

Table IV Compressive strength with different amount of SAP

Compressive strength with different amount of SAP				
Amount of SAP	*Curing Periods*	*Compressive strength (MPa)*		*Average Compressive strength(MPa)*
		Specimen 1	*Specimen 2*	
SAP 0.1 %	*3 Days*	11.48	11.79	**11.64**
	7 Days	20.85	20.79	**20.82**
	28 Days	32.15	32.25	**32.2**
SAP 0.2 %	*3 Days*	14.26	14.28	**14.27**
	7 Days	22.54	22.56	**22.55**
	28 Days	33.64	33.68	**33.66**
SAP 0.3 %	*3 Days*	13.30	13.36	**13.33**
	7 Days	23.65	23.69	**23.67**
	28 Days	35.51	35.59	**35.55**
SAP 0.4 %	*3 Days*	12.45	12.49	**12.47**
	7 Days	21.90	21.94	**21.92**
	28 Days	31.52	31.58	**31.55**

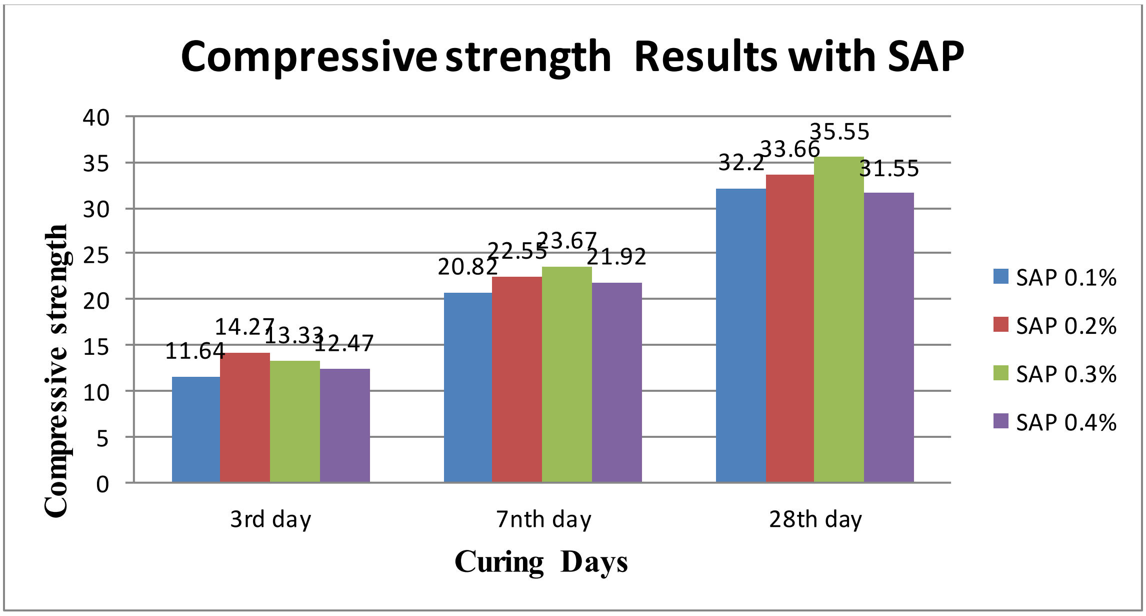


Chart I Compressive strength result with SAP

TENSILE STRENGTH OF CONCRETE

SPLIT TENSILE STRENGTH

A concrete cylinder of size 150mm dia×200mm height is subjected to the action of the compressive force along two opposite edges, by applying the force in this manner .The cylinder is subjected to compression near the loaded region and the length of the cylinder is subjected to uniform tensile stress.

$$Horizontal\ tensile\ stress = 2P/\pi DL$$

Table V Split Tensile strength with different amount of SAP

Split Tensile strength with different amount of SAP				
Amount of SAP	*Curing Periods*	*Split tensile strength (MPa)*		*Average Split tensile strength(MPa)*
		Specimen 1	*Specimen 2*	
SAP 0.1 %	*3 Days*	1.33	1.41	**1.37**
	7 Days	2.43	1.97	**2.2**
	28 Days	3.14	3.46	**3.3**
SAP 0.2 %	*3 Days*	1.22	1.32	**1.27**
	7 Days	2.03	2.19	**2.11**
	28 Days	3.87	3.93	**3.9**
SAP 0.3 %	*3 Days*	1.46	1.36	**1.41**
	7 Days	2.52	2.54	**2.53**
	28 Days	4.04	3.92	**3.98**
SAP 0.4 %	*3 Days*	1.16	1.24	**1.2**
	7 Days	1.98	2.22	**2.1**
	28 Days	3.61	3.67	**3.64**

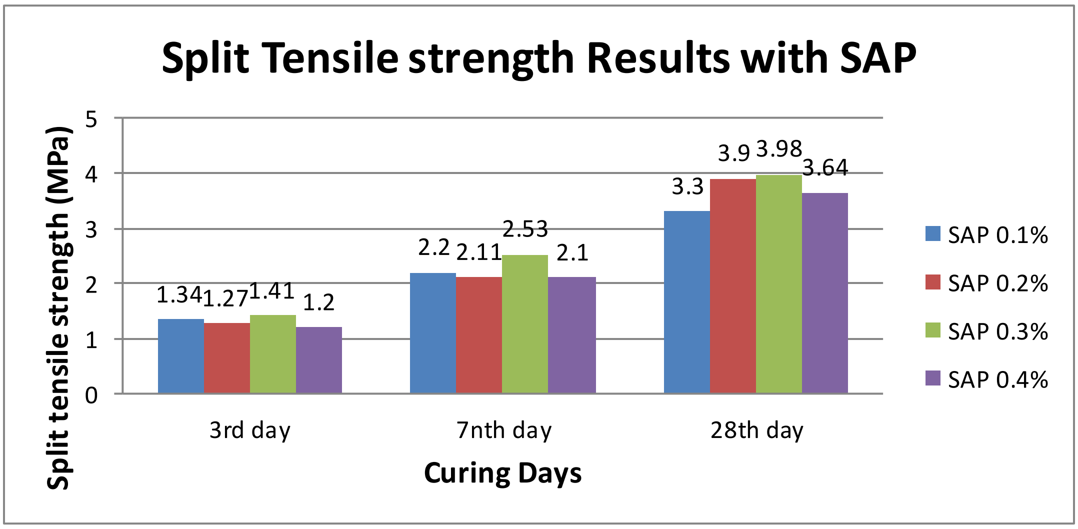


Chart II Split tensile strength result with SAP

FLEXURAL STRENGTH TEST

Flexural strength test or modulus of rupture carried out on the beams of size (100mm×100mm×500mm), by considering the material to be homogeneous .The beam should be tested on a span of 400 mm for 100mm specimen by applying two equal loads placed at third points .To get these loads, a central point load is applied on a beam supported on steel rollers placed at third point. The rate of loading shall be 1.8 KN/minute for 100 mm specimens the load should be increased until the beam failed .Note the type of failure, appearance of fracture and fracture load.

Let "a" be the distance between the line of fracture and the nearer support. Then for finding the modulus of rupture, these cases should be considered.

1. When a>133mm for 100mm specimen

$$Fcr=PL/bd^2$$

2. When 110mm<a<133mm

$$Fcr=3Pa/bd^2$$

TABLE VI Flexural strength with different amount of SAP

Flexural strength with different amount of SAP				
Amount of SAP	*Curing Periods*	*Flexural strength (MPa)*		*Average Flexural strength(MPa)*
		Specimen 1	*Specimen 2*	
SAP 0.1 %	*3 Days*	3.94	4.16	**4.05**
	7 Days	4.24	4.3	**4.27**
	28 Days	4.71	4.93	**4.82**
SAP 0.2 %	*3 Days*	4.1	4.22	**4.16**
	7 Days	4.43	4.53	**4.48**
	28 Days	5.51	5.35	**5.43**
SAP 0.3 %	*3 Days*	4.16	4.38	**4.27**
	7 Days	4.3	4.48	**4.39**
	28 Days	5.41	5.23	**5.32**
SAP 0.4 %	*3 Days*	4.12	4.28	**4.2**
	7 Days	4.65	4.79	**4.72**
	28 Days	5.34	5.18	**5.26**

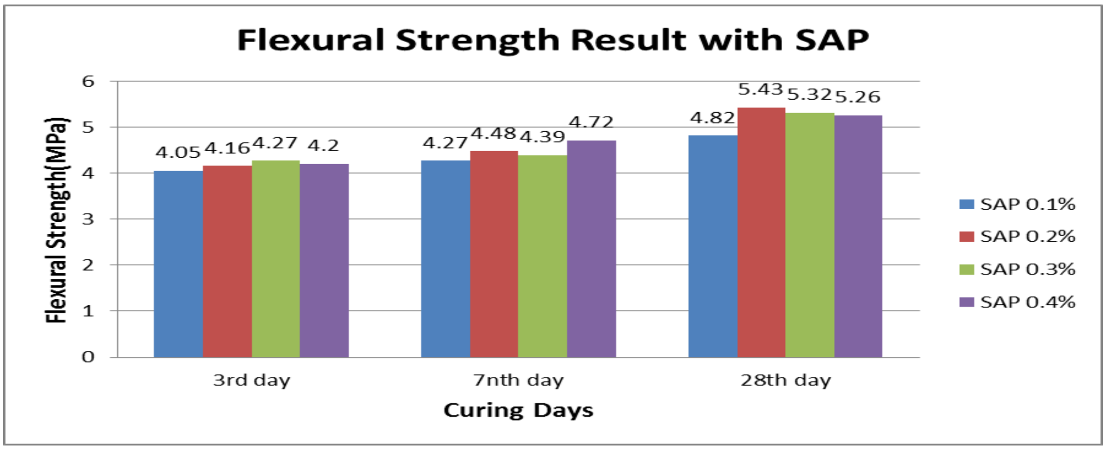


Chart III Flexural strength results with SAP

VI. CONCLUSION

Based on the investigation conducted for the study of behavior of self -compacted self -cured concrete the following conclusions are arrived.

1. As no specific mix design procedures for SCC are available, mix design can be done with conventional BIS method and suitable adjustments can be done as per the guidelines provided by different agencies.

2. Tests done in fresh properties showed results is within the specified limits.

3. The optimum dosage is 0.3%.Addition of SAP leads to a significant increase of mechanical strength (Compressive and Splitting tensile).

4. Compressive strength of self-cured concrete for dosage of 0.3% is higher.

5. Split tensile strength of self-cured concrete for dosage of 0.3% is higher.

6. Flexural Strength of self-cured concrete for dosage of 0.3%.

7. There was a gradual increase in the strength for dosage from 0.2 to 0.3% and later gradually reduced because the performance of the self-curing agent is affected by the mix proportions mainly the cement content and the water-cement ratio.

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