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TO STUDY THE STRENGTH CHARACTERISTICS OF CONCRETE BY REPLACING CURING WATER WITH SELF CURING COMPOUNDS

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ABSTRACT

In today's world, concrete is most popular and widely used material in construction sector due to its good compressive strength and durability. Depending upon its usability the mix proportion (cement, fine aggregate, coarse aggregate and water) are prepared to produce plain concrete. Plain concrete needs ambient atmosphere for curing for a minimum period of 28 days in order to attain desired strength. Any laxity in curing will badly affect the strength and durability of concrete. Self-curing concrete is one of the special concretes in mitigating insufficient curing due to human negligence, paucity of water in arid areas, inaccessibility of structures in difficult terrains and in areas where the presence of fluorides in water will badly affect the characteristics of concrete. The present study involves the use of shrinkage reducing admixtures like POLYETHYLENE GLYCOL (PEG 400) as internal curing compound and CUREFREE-C as external curing compound. These curing compounds are used in concrete which helps in self curing and helps in better hydration and hence good compressive strength. They trap the moisture within the structure and prevent it from evaporation (by creating a thin film or by block the pores containing water) which normally occurs due to the hydration process .In the present study, the affect of curing compounds on compressive strength and flexural strength is studied. From the previous studies by various researchers, we vary the percentage of PEG by weight of cement from 0% to 2% as the dosage of internal curing compound and 0.25% of CUREFREE-C by weight of cement was fixed as the dosage of external curing compound The test results were studied both for M25 and M30 mixes .The results shows that PEG 400 and CUREFREE-C could help in self curing by giving strength on par with that of the conventional curing method.

***Keywords**: Curing, Polyethylene Glycol, Curefree-C, Strength Characteristics*

INTRODUCTION

Curing can be performed in a number of ways to ensure that an adequate amount of water is available for cement hydration to occur. However, good curing is not always practical in many cases. Negligence given to proper curing at construction sites has been a topic of discussion since a very long time. Several investigators asked the question whether there will be self-curing concrete. Therefore, the need to develop self-curing agents attracted several researchers. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete. These compounds will rise to the finished concrete surface and effectively seal the surface against evaporation. It was found that water soluble polymers can be used as self-curing agents in concrete.

The use of self-curing admixtures is very important from the point of view that water resources are getting valuable every day (i.e., each 1 m^3 of concrete requires about 3 m^3 of water for construction most of which is for curing).The benefit of self-curing admixtures is more significant in desert areas where water is not adequately available.

OBJECTIVE

The main objective is to evaluate the use of self-curing agent in place of conventional curing method (Ponding Method). In this study strength of concrete containing self-curing agents (Using internal as well as external curing agents) is investigated and compared to that of conventional concrete.

S. No.	Type of Concrete Mix for one grade
1	Conventional concrete mix
2	Concrete mix with PEG-400 as internal curing compound with different proportions.
3	Concrete mix with CUREFREE-C as external curing compound

Table 1: Combination of various mixes

Chemical Substances Used in the Study:

- **POLY ETHYLENE GLYCOL-400(PEG-400) (Used as an internal curing compound):-**

Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula $H(OCH_2CH_2)_nOH$, where n is the average number of repeating oxyethylene groups typically from 4 to about 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be the water-soluble nature. Polyethylene glycol is non-toxic, odourless, neutral, lubricating, nonvolatile and non-irritating and is used in a variety of pharmaceuticals. Thus, it is a shrinkage reducing admixture.

- **CUREFREE-C (Used as an external curing compound):-**

It is a Liquid membrane-forming curing compound and is used on the principle that concrete gets enough water from pre-matured concrete for uninterrupted hydration after placement. For application on freshly cast concrete or newly exposed concrete surface after removal of formwork to form a temporary membrane which will provide sufficient moisture for effective curing to take place. The membrane eventually breaks down and disintegrate after which the surface can be painted. It is useful for large areas of concrete such as pavements, runways, bridge decks and industrial floors. It is also used for vertical or sloping surface as of chimneys, towers, silos, canal lining, columns and beams where water curing is difficult or unreliable.

S. No.	NATURE OF CURING	M25		M30	
		CUBE	BEAM	CUBE	BEAM
1.	CONVENTIONAL(PONDING)	6	6	6	6
2.	EXTERNAL CURING (CUREFREE-C)	6	6	6	6
3.	INTERNAL CURING (PEG-400 having quantity 0.5%)	6	6	6	6
4	INTERNAL CURING (PEG-400 having quantity 1%)	6	6	6	6
5	INTERNAL CURING (PEG-400 having quantity 1.5%)	6	6	6	6
6	INTERNAL CURING (PEG-400 having quantity 2%)	6	6	6	6

Table 2: Specimens casted for testing purpose

Experimental work conducted:

Various test were done on the ingredients of concrete to collect data require for mix design as well as to study their physical properties. The proportions of ingredients for M25 and M30 for all the three types of mixes were determined by mix design and same proportions were used for casting the concrete specimens (cubes and beams).

I. Mix designs were done as per IS: 10262-2009.
II. Materials were weighed by weigh batching.
III. Each set consists of 2 specimens (cubes and beams) and the test strength of the sample has been taken as the average strength of the specimens.

IV. 72 numbers of cubes 150mm x 150mm x 150mm were casted to determine the compressive strength of various mixes of concrete at the end of 7 and 28 days.

V. 72 numbers of beams 100mm x 100mm x 500mm were casted to determine the flexural strength of various mixes of concrete at the end of 7 and 28 days.

The details of all the mix design are shown in the table below:-

MIX	W/C RATIO	CEMENT	WATER	FA	CA
		Kg	Kg	Kg	Kg
Conventional	0.50	395	195.24	642.62	1164.14
PEG-400	0.50	395	195.24	642.62	1164.14
CUREFREE-C	0.50	395	195.24	642.62	1164.14

Table 3 Mix design proportions of various mixes for M25 grade of concrete

MIX	W/C RATIO	CEMENT	WATER	FA	CA
		Kg	Kg	Kg	Kg
Conventional	0.45	438	195.57	611.25	1159.2
PEG-400	0.45	438	195.57	611.25	1159.2
CUREFREE-C	0.45	438	195.57	611.25	1159.2

Table 4 Mix design proportions of various mixes for M30 grade of concrete

Material Used	Quantity in Kg for M25	Quantity in Kg for M30
Conventional concrete mix	0	0
PEG 400 (0.5% of cement content)	1.96	2.19
PEG 400 (1% of cement content)	3.95	4.38
PEG 400 (1.5% of cement content)	5.93	6.57
PEG 400 (2% of cement content)	7.9	8.76
CUREFREE-C (0.25% of cement content)	0.988	1.1

Table 5: Quantity of various proportions of PEG 400 and Curefree- C in both mixes

TEST RESULTS FOR VARIOUS MIXES:

Average Compressive and Flexural strength for 7 and 28 days obtained by taking average of 3 specimens for each day are compiled below.

MIX	AVERAGE COMPRESSIVE STRENGTH(N/mm^2)		AVERAGE FLEXURAL STRENGTH(N/mm^2)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
CONVENTIONAL CURING	23.26	32.29	3.92	5.18
PEG PROPRTION 0.5%	19.6	28	2.32	3.3
1%	21.49	38.7	2.58	3.6
1.5%	22.3	31.8	2.53	3.7
2%	21	30	2.18	3.1
CUREFREE-C (.25%)	22.19	31.7	2.75	3.9

Table 6 Comparative Strength test results of various mixes for M25 Grade of Concrete (Target strength is 31.6 N/mm^2)

Analysis and comparative study of Compressive strength for various proportion of PEG 400 for M25 grade of concrete

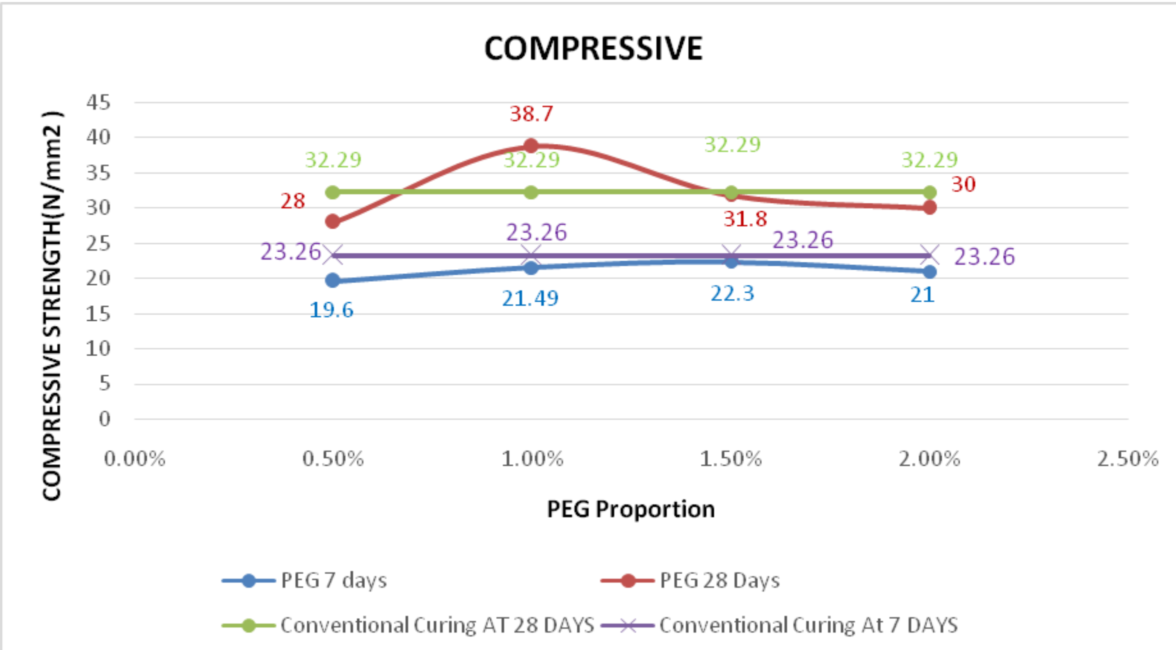

Figure 1: Compressive Strength of M25 grade concrete for various proportion of PEG 400

The compressive test done on concrete cubes for all the three mixes for 7 and 28 days are depicted in the figure above. The pattern above clearly depicts that the concrete made from internal and external curing agents shows at par strength as compared to concrete made from normal (conventional) curing. Concrete made from curing compounds doesn't fall short of the minimum strength requirement i.e. 25MPa.The strength achieved from curing compounds is more than 25 MPa.

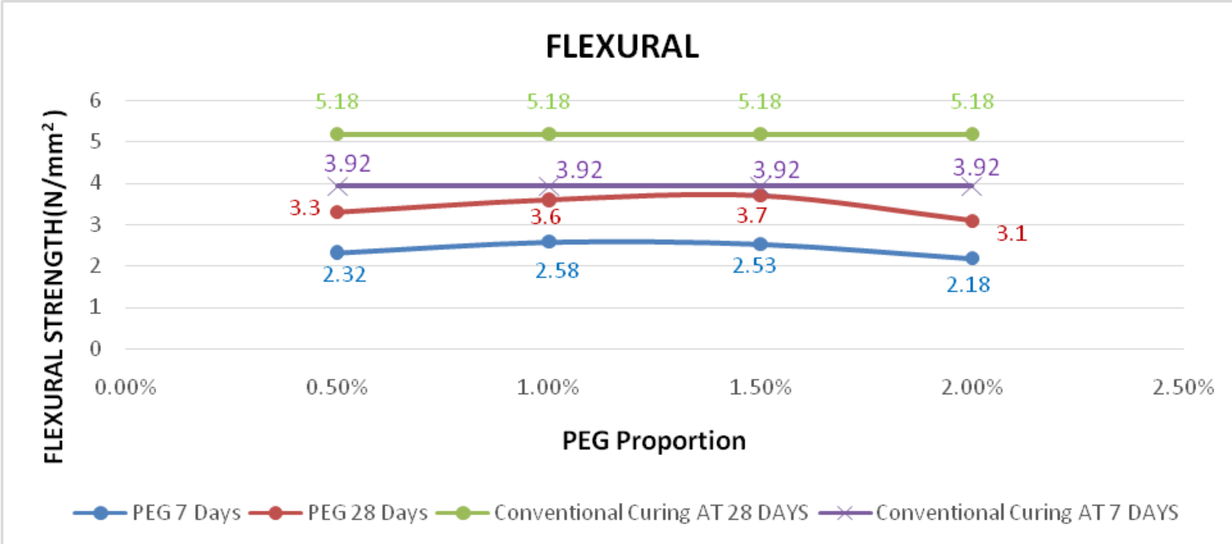

Figure 2 : Flexural Strength of M25 grade concrete for various proportion ofPEG 400

The Flexural test done on concrete beams for all the mixes for 7 and 28 days are depicted in the figure above. The pattern above clearly depicts that the concrete beam made from PEG-400 and CUREFREE-C shows at par flexural strength as compared to concrete made from conventional curing. Concrete made from curing compounds doesn't fall short of the minimum strength requirement as per codal provisions for M25 grade of concrete i.e. $0.7(fck)^{1/2}$. The strength achieved from curing compounds is much above the required value.

MIX	**AVERAGE COMPRESSIVE STRENGTH (N/mm²)**		**AVERAGE FLEXURAL STRENGTH (N/mm²)**	
	7 days	**28 days**	**7 days**	**28 days**
CONVENTIONAL	**28.29**	**39.48**	**3.93**	**5.04**
PEG 0.5%	**24.77**	**35.40**	**2.65**	**3.82**
1 %	**27.3**	**37.7**	**2.98**	**4.11**
1.5%	**28.8**	**38.9**	**2.99**	**4.32**
2.0%	**26.11**	**37.4**	**3.1**	**4.09**

CUREFREE-C (0.25%)	27.19	38.8	3.13	4.37

Table7 Comparative Strength test results of various mixes for M30 grade of concrete (Target strength is 38.25 N/mm^2)

Analysis and comparative study of Compressive strength for various proportion of PEG 400 for M30 grade of concrete

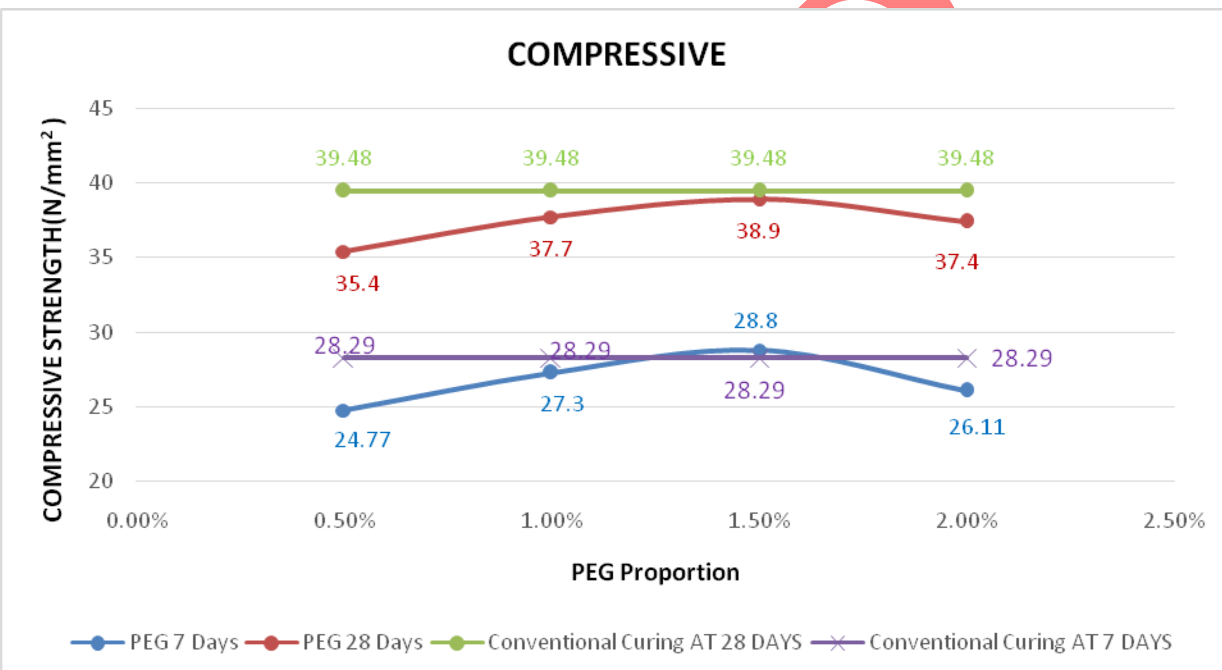

Figure 3: Compressive Strength of M30 grade concrete for various proportion of PEG 400

The compressive test done on concrete cubes for all the three mixes for 7 and 28 days are depicted in the figure above. The pattern above clearly depicts that the concrete made from internal and external curing agents shows at par strength as compared to concrete made from normal (conventional) curing. Concrete made from curing compounds doesn't fall short of the minimum strength requirement i.e. 30 MPa. The strength achieved from curing compounds is much above 30 MPa.

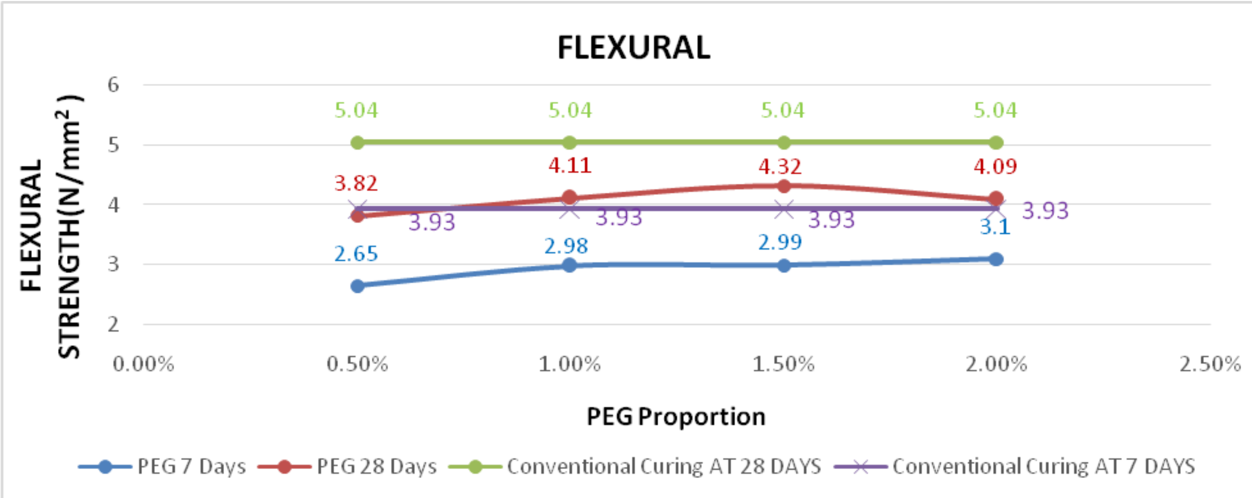

Figure 4: Flexural Strength of M30 grade concrete for various proportion of PEG 400

The Flexural test done on concrete beams for all the mixes for 7 and 28 days are depicted in the figure above. The pattern above clearly depicts that the concrete beam made from PEG-400 and CUREFREE-C shows at par flexural strength as compared to concrete made from conventional curing. Concrete made from curing compounds doesn't fall short of the minimum strength requirement as per codal provisions for M30 grade of concrete i.e. $0.7(f_{ck})^{1/2}$. The strength achieved from curing compounds is much above the required value.

RESULTS

The test results are obtained by keeping the mix proportions constant without any inclusion of plasticizers and super-plasticizers. Only curing compounds are additionally added in the mix as a substitute of curing water.

- The Strength of concrete achieved by conventional curing is at par as compared to internal and external curing methods. The results obtained from conventional curing method (ponding) are under ideal conditions when the specimens are kept completely submerged in water for 7 days and 28 days. Such long and ideal curing conditions may not be possible under actual site conditions. Thus these results do not give a true picture of conditions existing at construction sites.
- Concrete mixes prepared using curing compounds are at par with specified target strength values calculated during design mix for both M25 and M30 grade of concrete. Also it can be seen that more than the minimum strength as per the codal provisions has been achieved by the specimens cured through curing compounds. The strength achieved by

the PEG-400 and CUREFREE-C is comparable for both types of mix i.e. M25 and M30. The results obtained after the use of curing compounds show a better picture of the actual site conditions in comparison to those obtained from conventional curing techniques. Only the environmental conditions existing at site and laboratory may vary. Rest all parameters are more or less the same.

- The Compressive Strength achieved by cubes and beams cured through curing compound (both PEG-400 and CUREFREE-C) is 20% more than that achieved through conventional curing method for M25 and is nearly 99% of that achieved through conventional curing method for M30 grade of concrete.
- The Flexural Strength achieved by cubes and beams cured through curing compound (both PEG-400 and CUREFREE-C) is nearly 71% of that achieved through conventional curing method for M25 and is 86% of that achieved through conventional curing method for M30 grade of concrete.
- The extra cost of procuring water from deep underground or far off sources specially in developing areas can be saved by the use of curing compounds. Also conditions supervision by labour to ensure good moisture and temperature conditions for maintaining satisfactory curing conditions is avoided. Thus any fault or delay in curing would not affect the structural strength in the long run.

CONCLUSIONS

On the basis of Experimental tests results and observations, following conclusions are made:

1. As per the results compiled in tables 5.4& 5.5,compressive strength of various mixes for M25 and M30 Grade of concrete we conclude that the compressive strength of mixes using self curing compounds (PEG-400& CUREFREE) are at par with that of the concrete with conventional curing.

2. As per the results in figure 5.2 and 5.4 flexural strength of various mixes for M25 and M30 Grade of concrete we conclude that the flexural strength of mixes using self curing compounds (PEG-400 & CUREFREE) are at par with that of the concrete with conventional curing.

3. The compressive strength achieved through curing compound (CUREFREE-C) is 20% more than that achieved through conventional curing method for M25 and is nearly 99% of that achieved through conventional curing method for M30 grade of concrete.

4.The Flexural Strength achieved by cubes and beams cured through curing compound (both PEG-400 and CUREFREE-C) is nearly 71% of that achieved through conventional curing method for M25 and is 86% of that achieved through conventional curing method for M30 grade of concrete.

5. It can be seen that the minimum strength as per the codal provisions has been achieved by the specimens cured through curing compounds. The strength achieved by the PEG-400 and CUREFREE-C is comparable for both types of mix i.e. M25 and M30. The results obtained after the use of curing compounds show a better picture of the actual site conditions in comparison to those obtained from conventional curing techniques.

6. Any laxity in curing badly affects the strength and durability of concrete. India has predominantly hot climate for most of the year. Within 2 or 3 hours, high ambient temperature and evaporation causes rapid shrinkage on freshly completed concrete structures, resulting in shrinkage cracks.

7. Depletion of water resources at a very fast rate is a very big concern these days. Water resources needs to be conserved specially in arid regions where there is a lot of water scarcity. It is said that $1m^3$ of concrete requires nearly 3 m^3 of water for construction most of which is for curing.

All this led to the need to develop self-curing agents. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete. These compounds will rise to the finished concrete surface and effectively seal the surface against evaporation.

The aim of the project was to compare the test results based on curing conditions only. No changes have been done in the mix design for the mix. The results achieved from the tests conducted on specimen casted using curing compounds are very satisfactory. Results show that there is continuous increase in the strength of specimens for a period of 28 days. Higher strength results can be easily achieved by the use of plasticizers and super–plasticizers, reduction of water cement ratio and the addition of external cementitious compounds. Curing compound has the advantage of being used and left with no further maintenance. The strength results of conventionally cured specimens have been obtained after 28 days of proper curing which may not be possible at site as continuous vigilance is required to see that the surface moisture is not lost. In this regard, the strength results obtained by the use of self curing compounds are at par with that of site conditions.

Thus our experimental study has been successfully completed. We have been able to achieve good concrete quality with sufficient strength. The results show that curing compounds have the potential of replacing water as the curing agent. Further study is required to check the durability of self cured concrete structures. With research work going on in this field, self cured concrete will become very common and curing compounds will again a lot of importance in the upcoming years.

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