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An Experimental Study on Partial Replacement of Fine Aggregate As a Quarry Dust In Concrete

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ABSTRACT

Concrete is the most widely used construction material today. The constituents of concrete are coarse aggregate, fine aggregate binding material and water. Rapid increase in construction activities leads to acute shortage of conventional construction materials. It is conventional that sand is being used as fine aggregate in concrete. For the past some years, the escalation in cost of sand due to administrative restrictions in India, demands comparatively greater cost at around two to three times the cost of quarry dust even in places where river sand is available nearby. To achieve economy, it is proposed to study with the use of crusher powder, a quarry waste as an alternative material to replace sand by crusher powder. There was a remarkable increase in compressive strength of concrete with 20% replacement of sand with manufactured sand. 40% replacement is possible and 50% replacement gave higher strength. Quarry dust fine aggregate decreased the compressive strength due to deficient grading and excessive flakiness. The w/c ratio and slump value increased with the replacement of sand, Voids present in quarry dust mortar were lesser as compared to that of sand hence higher compressive strength. A comparatively good strength is expected when sand is replaced partially or fully with or without concrete admixtures.

Keywords: Aggregate, Admixture, Escalation

I. INTRODUCTION

It is proposed to study the possibility of replacing sand with locally available quarry dust without sacrificing the strength and workability of concrete. Coarse aggregate is an important material used in R.C.C work of all types of structures. This is obtained by crushing the stone boulders of size 100 to 150mm in the stone crushers. The aggregate is sieved and the sieved aggregates which is less than 4.75mm in size, used in building construction works is called quarry dust. This dust is heaped like a mountain near the stone crushers. The volume of the waste dust produced is increased day by day. The owners of the crushers find it difficult to clear the dust from the crusher units. In highways department the quarry dust is used to sprinkle over the newly laid bituminous road as a binding material between the bitumen and coarse aggregate. The fine powder from quarry dust is mixed with cement and used in grouting works. The quarry dust is used in the manufacturing of hollow blocks. Some mosaic companies use quarry dust partly for sand.

General Applications:

The reduction in the sources of sand and the need to reduce the cost of construction projects has resulted in the increase need to identify alternative construction materials to sand as fine aggregates in the construction projects.

Quarry dust a by- product from crushing process during quarrying activities is good alternative during construction projects. It is used as substitute to sand to make **quarry dust concrete** which is believed to be stronger and more durable than the regular concrete materials. It can be used as substitute to sand wholly or partly. It offers a comparatively good strength compared to sand with or without concrete admixtures.

II. LITERATURE REVIEW

The suitability of quarry dust as a sand replacement material shows that the mechanical properties are improved and also elastic modulus.

The suitability of quarry dust as a sand replacement material shows that the mechanical properties are improved and also elastic modulus. The compressive

strength achieved optimum by replacing fine aggregate with quarry dust in ratio of 60 : 40 as done by Hmaid Mir.
Felekoglu et al observed that the incorporation of quarry waste at the same cement content generally reduced the super plasticizer requirement and improved the 28 days' compressive strength of SCC. Normal strength SCC mixtures that contain approximately 300–310 Kg of cement per cubic meter can be successfully prepared by employing high amount of quarry waste Sukumar et al. found that the relations have been established for the increase in compressive strength at premature ages of curing (12 h to 28 days) for different grades of SCC mixes and are compared with the IS Code formula for straight concrete as per IS: SP 23-1982

Ho et al. explained that the granite fines can be used in the SCC production. However, it is important to spot out that, as a waste material, the properties of stone fines are likely to vary with time. Then, after that, the fineness of granite fines could solve durability problems, such as silica-alkli reactaions. These two issues would require to be addressed if the material is to be used with assurance.

Muhit et al determined that passing from 200 mm sieve is used as cement replacement whereas retaining from 100 mm sieve is used as sand replacement. Cement was replaced with stone dust in percentage of 3, 5, and 7 percent. Similarly, sand was replaced with stone dust in percentage of 15 to 50 with an increase of 5 percent. Test result gives that compressive strength of mould with 35% of sand and 3% of cement replacing dust increases to 21.33% and 22.76% in that order compared to the normal mortar mould at 7 and 28 days for tensile strength which increased to 13.47%.

Ukpata and Ephraim identified the flexural and tensile strength properties compared with those for normal concrete. Hence, concrete proportion of lateritic sand and quarry dust can be used for construction provided the mixture of lateritic sand content is reserved below 50%. Both flexural strength and tensile strength are increased with increase in lateritic content.

According to Soutsos et al the physical characteristics of recycled destruction aggregates may unfavorably affect the properties of the blocks. However, levels of replacement of quarried stone aggregates with destruction recycled aggregates determined that it will not have significant harmful effect on the compressive strength.

Concrete containing quarry dust as fine aggregate can be effectively utilized in the construction industry with good quality materials, appropriate dosage of super plasticizer, appropriate mixing methods, and proper curing thereby ensuring sustainable development against environmental pollution (Devi and Kannan).

The study of Ilangovana et al gives attention to physical and chemical properties of quarry dust with respect to requirements of codal provision which are satisfied. The 100% replacement of sand with quarry dust gives better results in terms of compressive strength studies..

III. MATERIALS AND METHODOLOGY

3.1 Materials used:

3.1.1 Cement:

Cement as it commonly known, is a mixture of compounds made by burning limestone and clay together at very high temperature ranging from 1400 to 1600 c. although there are other cements for special purposes, this project will focus solely on Portland cement and its properties.

3.1.2 Water:

Water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregates together. The water causes the hardening of concrete through a process called hydration. Hydration is a chemical reaction in which the major compounds in cement form chemical bonds with water molecules and become hydrates or hydration products. The water needs to be pure in order to prevent side reactions from occurring, which may weaken the concrete or otherwise interfere with the hydration process. The role of water is important because the water to cement ration is the most critical factor in the production of "perfect" concrete. Too much water reduces concrete strength, while too little will make the concrete unworkable. Concrete needs to be workable so that it may be consolidated and shaped in to different forms (I.e. walls, domes, etc). Because concrete must be both strong and workable, a careful balance of the cement to water ratio is required when making concrete. Portable water is considered satisfactory for mixing concrete. The water should be colorless and free from any smell. The presence of chlorides and sulphates are injurious to reinforcing bars as they may be corroded.

3.1.3 Aggregates:

Aggregates are chemically inert, solid bodies held together by the cement. Aggregates come in various shapes, sizes and materials ranging from fine particles of sand to large course rocks. Because cement is the most expensive ingredient in making concrete, it is desirable to minimize the amount of cement used. 70 to 80% of the volume of concrete is aggregate keeping the cost of the concrete low. The selection of aggregate is determined, impart by the desired characteristics of the concrete. For example, the density of the aggregate determines the density of concrete. Soft, porous aggregates can result in weak concrete with low wear resistance, while using hard aggregates can make strong concrete with a high resistance to abrasion.

Aggregates should be clean, hard and strong. The aggregate is usually washed to remove any dust, silt, clay, organic matter or other impurities that would interfere with the bonding reaction with the cement paste. It is then separated in to various sizes by passing the materials through a series of screens with different size openings.

3.1.4 Fine Aggregates:

The fine aggregate locally was used in this investigation. The aggregate was sieved through IS sieve. The fine aggregate or sand may be natural or crushed. It may be available in a riverbed or in a quarry. The sizes of sand particles vary from a maximum of 4.75mm down to 150micron i.e. 0.150mm. Good sand must contain all the particles with in the above range that is and it should be graded sand. The sand may be sieved through the Indian standards sieves: 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron and 150 micron. The sand may be classified as VERY COURSE (ZONE 1), MEDIUM COURSE (ZONE 2), COURSE (ZONE 3) and FINE (ZONE 4) depending upon its grain size distribution.

3.1.5 Coarse Aggregate:

The course aggregate may be natural or crushed gravel. It may have a maximum size of 20 mm down to 4.75 mm and should be graded. It should be clean, and free from dust and other impurities. It should be stored separately from sand or lime etc. on a hard surface. If necessary, the aggregate may be washed and dried for 72 hours before use. Moist or wet aggregate should be used in construction. The aggregate consists of over 75% of concrete mix. Therefore save cement by using clean and graded aggregate having proper shape and size

3.1.6 Quarry Dust:

Quarry dust is a by product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste. So it becomes as a useless material and also results in air pollution. Therefore, quarry dust should be used in construction works, which will reduce the cost of construction and the construction material would be saved and the natural resources can be used properly. Most of the developing countries are under pressure to replace fine aggregate in concrete by an alternate material also to some extent or totally without compromising the quality of concrete. Quarry dust has been used for different activities in the construction industry, such as building materials, road development materials, aggregates, bricks, and tiles.

Quarry Dust

3.1.7 Admixture:

Conplast SP420 is a chloride free, superplasticising admixture based on selected sulphonated naphthalene polymers. It is supplied as a brown solution which instantly disperses in water.

Conplast SP420 disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively. The very high levels of water reduction possible allow major increases in strength to be obtained.

Uses

- ✓ To provide excellent acceleration of strength gain at early ages and major increases in strength at all ages by significantly reducing water demand in a concrete mix.
- ✓ Particularly suitable for precast concrete and other high early strength requirements.
- ✓ To significantly improve the workability of site mixed and precast concrete without increasing water demand.
- ✓ To provide improved durability by increasing ultimate strengths and reducing concrete permeability.
- ✓ In screeds it reduces the water content required to give suitable workability for placing and compaction.

IV. EXPERIMENTAL TEST

4.1 Slump Cone Test:

The concrete stoop test is an empirical take a look at that measures workability of clean concrete. The hunch cone check shows the behavior of a compacted concrete cone below the movement of gravitational forces. The test is performed with a Moulds known as as hunch cone. The stoop cone is located on a horizontal and a non-absorbent floor and filled in three layers of fresh concrete, each layer being tamped 25 instances with a widespread tamping rod. Take a look at is appropriate handiest for concretes of medium to excessive workability's (i.e. Having stoop values of 25mm to 125mm).

The metallic plate i.e. Base is placed on a clean floor and the container is full of bacterial concrete in 3 layers, whose workability is to be tested. Each layer is temped 25 times with a well known sixteen mm (five/eight in) diameter steel rod, rounded at the cease. When the mould is completely packed with bacterial concrete, the pinnacle floor is struck off (levelled with Moulds pinnacle establishing) through screening and rolling motion of the temping rod. The Moulds firmly held against its base for the duration of the complete operation so that it could not pass due to the pouring of concrete with the aid of handles or foot - rests. Immediately after filling is finished and the concrete is leveled, the cone is slowly and punctiliously lifted vertically, an unsupported bacterial concrete will now hunch. The droop is measured. The decrease in height of concrete to that of Moulds is mentioned with scale that is located to be 110mm for traditional concrete and 50mm for bacterial concrete. Figure suggests the overall performance of stoop cone test.

Slump cone test

4.2 Compaction factor test:

Keep the compaction factor apparatus on a level ground and apply grease on inner surface of hoppers and cylinder. Fasten the flap doors. Weigh the empty cylinder accurately and note down the mass W1 Kg_ Fix the cylinder on the base with fly nuts and bolts in such a way that the centre points of hoppers and cylinder lie on the one vertical line. Four mixes are prepared with water cement ratio 0.5,0.6,0.7, andO.8.Fill the freshly mixed concrete in the upper hopper gently and carefully with hand scoop with out compacting.

After two min, release the trap door so that the concrete-fall in to the lower hopper bringing the concrete in to the standard compaction.

Immediately after the concrete has come to rest, open the trap door of lower hopper and allow the concrete fall in to cylinder bringing concrete in to standard compaction. Remove the excess of concrete above the top of the cylinder. Clean the cylinder from all sides properly; find the mass of the partially compacted concrete thus filled in the cylinder.

Refill the cylinder with the same sample of concrete approximately 50mm layers. Struck off and level the concrete then weigh the concrete. Let the mass be W3 kg

4.3 Compression Test

Casting of Cube Specimens for Compression Test:

The steel moulds were coated with oil on their inner surfaces and were placed on the platform. The amount of cement, Steel Fibres, sand and coarse aggregate required 30 cubes were weighted. The materials were first dry mixed then with water mixed thoroughly to get homogeneous mix. Concrete was poured into the moulds, after 24 hours concrete cubes were removed from moulds and specimens were kept for curing.

Testing machine:
The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified.

Age at test:
Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Ages of 13 weeks and one year are recommended if tests at greater ages are required. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours+_1/2 hour and 72 hours+_1 hours. However age of 7,28 and 42 days are considered for this investigation.

Number of specimens:
At least three specimens, preferably from different batches, shall be made for testing at each selected age.

Procedure
Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and girt shall be wiped off the specimens are any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the specimens to the nearest 0.2mm and their weight shall be noted before testing.

Placing the specimens in the testing specimen:
The bearing surfaces of the testing machine shall be wiped clean any loose sand or any other material removed from the surfaces of the specimen which are to be in contact with the compression platens.

In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The load shall be applied without shock and increased continuously at a rate of approximately 140kg/sq m/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained.

The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any usual features in the type of failure shall be noted.

The compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest KN per sq cm.

$$F=P/A, N/mm^2$$

Where F, compressive strength of concrete
P, ultimate load taken by concrete
A, C/s area over which load is acting

4.4 Flexural Test
The moulds (100mmx100mmx500mm) were cleaned and coated with oil on their inner surfaces and were placed on the platform. The amount of cement, fly ash, sand and coarse aggregate required 48 Beam specimen were weighed. The materials were first dry mixed then mixed with $1/3^{rd}$ amount of total water. Super plasticizer mixed with left amount of water is now added and mixed thoroughly to get homogeneous mix in mixer. Then time at slump flow at T50 cm, slump diameter, V-funnel test and L-box test were conducted to measure degree of workability of mix. Concrete was poured into the moulds, after 24 hours concrete cubes were removed from moulds and specimen were kept for curing. These specimen were tested Compression machine for 7,14,21 and 28 days respectively.

Testing Machine:
The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified.

Age at Test:
Tests shall be made at recognized ages of the test specimens, the most usual being 7.14,21 and 28 days. Ages of 13 weeks and one year are recommended if tests

at greater ages are required. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours±$^1/_2$ hour and 72 hours ±1hours. The ages shall be calculated from the time of addition of water to the dry ingredients. However ages of 7, 14, 21 and 28 days is considered for this investigation.

Number of Specimens:

At least 3 specimens, preferably from different batches, shall be made for testing at each selected age.

Procedure:

Test specimen stored in water at a temperature of 24^0 to 30^0 for 48 hours before testing,shall be tested immediately on removal from the water whilst they are still in wet condition.The dimensions of the each of the specimen shall be noted before testing. No preparation of the surface is required.

Placing the specimen in the testing machine:

The bearing surfaces of the supporting and loading roller shall be wiped clean, and any loose Sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers. The specimen than shall be placed in the machine in such a manner that the load shall be applied to the upper most surface as cast in mould, along two lines spaced 20cm or 13.3cm apart. The axis of the specimen shall be carefully aligned with the axis of the loading device. No packing shall be used between the bearing surfaces of the specimen and the rollers. The load shall be applied with out shock and increasing continuously with the rate such that the extreme fibres stress increases at approximately 7kg/sqcm/min, that is, at a rate of loading of 400kg/min for 15.0cm specimen and at a rate of 180kg/min for 10.0cm specimens. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded. The appearance of the fractured faces of concrete and any unusual features in the type of failure shall be noted.

The flexural strength of the specimen shall be expressed as the modulus of rupture f_b, which, if 'a' equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5kg/sq cm as follows,

$$\mathbf{f_b=(pxl)/(bxd^2)}$$

When 'a' is greater than20.0cm for 15.0cm specimen, or greater than13.3 cm for a 10.0cm specimen, or

$$\mathbf{f_b=(3xpxa)/(bxd^2)}$$

when 'a' is less than 20.0cm but greater than 17.0cm for 15.0cm specimen, or less than 13.3cm but greater than 11.0cm for a 10.0cm specimen where

b=measured width in cm of the specimen,

d=measured depth in cm of the specimen at the point of failure,

l=length in cm of span on which the specimen was supported, and

p=maximum load in kg applied to specimen,

If 'a' is less for than 17.0cm for a 15.0cm specimen, or less than 11.0cm for a 10.0cm specimen, the results of the test shall be discarded.

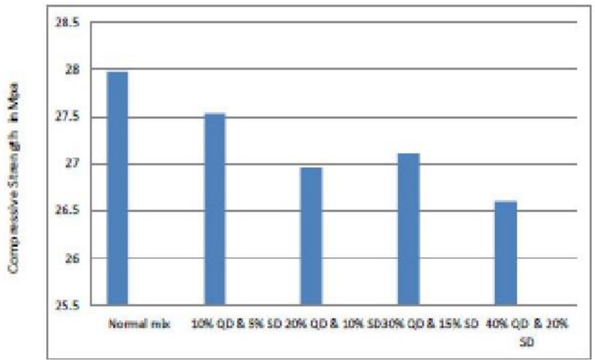
V. EXPERIMENTAL RESULT

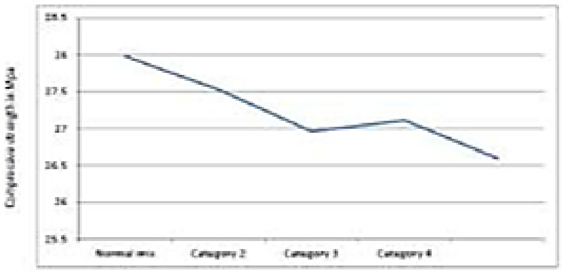
5.1 Compressive strength test results:

For each concrete mix, the compressive strength is determined on three 150×150×150 mm cubes at 7 and 28 days of curing.

Compressive strength of RHA concrete for 7 days

Mix Designation	**Curing period**	**Compressive strength (N/mm^2)**	**Avg Compressive strength (N/mm^2)**
M0	7 days	28.88	27.25
		30.66	
		22.22	
M1	7 days	27.55	28.21
		28.44	
		28.66	
M2	7 days	32.88	32.58
		31.55	
		33.33	
M3	7 days	35.55	35.70
		36.00	
		35.55	
M4	7 days	29.77	28.88
		28.00	
		28.88	





28th day Compressive strength result

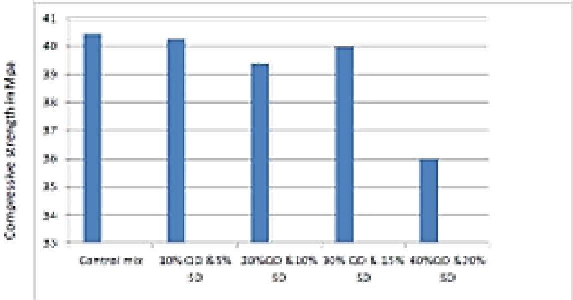
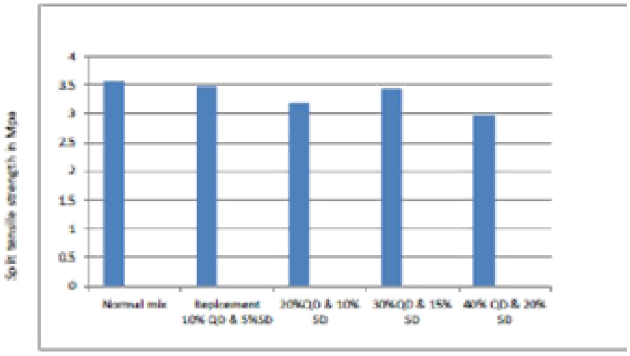
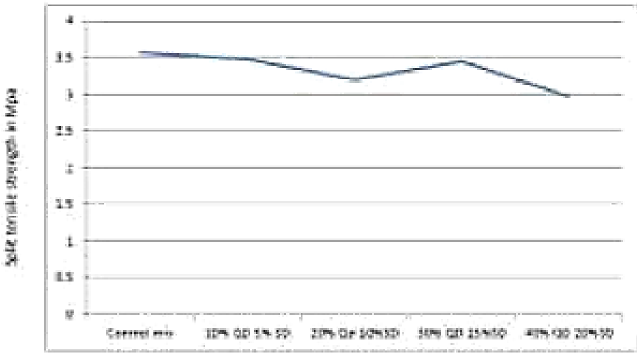


Table gives the 7th and 28th day of compressive strength test results conducted for control mix and replacement of fine aggregate with different percentage of quarry dust The bar chart indicates that the better result obtained with an optimum percentage of 30% and 15% by quarry dust respectively

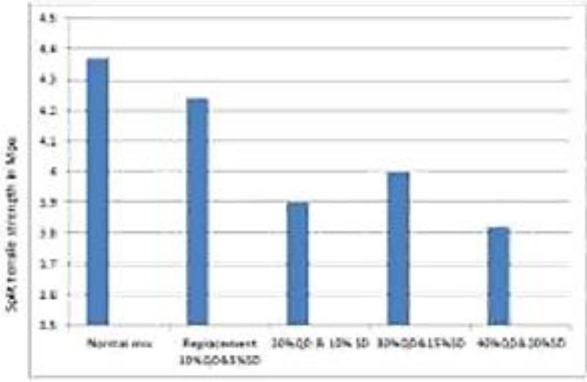
Overall results of SPLIT TENSILE STRENGTH RESULTS:

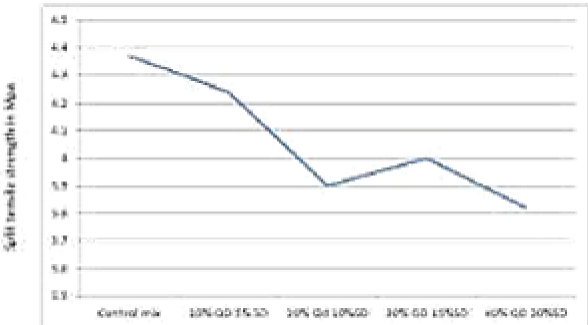
Mix Designation	SPLIT TENSILE STRENGTH RESULTS (N/mm^2)	
	7 Days Curing	28 Days Curing
M0	3.57	4.37
M1	3.48	4.34
M2	3.20	3.90
M3	3.45	4.00
M4	2.97	3.82





From the above graph indicates the results it was observed that the split tensile strength is obtained for mix 30% quarry dust replacement at the water cement ratio 0.45. The above result clearly indicates that the split tensile strength decreases up to 20% by quarry dust but it increases by replacement of 30% by quarry dust





VI. DISCUSSION OF RESULTS AND CONCLUSION

1. Table gives the 7th and 28th day of compressive strength test results conducted for control mix and replacement of fine aggregate with different percentage of quarry dust The bar chart indicates that the better result obtained with an optimum percentage of 30% and quarry dust respectively
2. From the above graph indicates the results it was observed that the split tensile strength is obtained for mix 30% quarry dust replacement at the water cement ratio 0.45. The above result clearly indicates that the split tensile strength decreases up to 20% by quarry dust but it increases by replacement of 30% by quarry dust
3. The weight can be reduced upto 20%.

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