EXPERIMENTAL INVESTIGATION ON CONCRETE USING OIL PALM SHELL

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ABSTRACT

***Objectives**: To create a new composite material which can be derived from the existing waste materials. The composite material is a combination of Ordinary Portland Cement and Oil Palm Shell. It replaces the non-availability of natural building materials.*
***Methods**: It is the method of extracting wealth from the waste. The test results of different mixtures are analysed. The composite mixture having high quality with low cost is selected for future use as a non-conventional building material named as Light Weight Aggregate (LWA). This LWA is used as Light weight concrete. The coarse aggregates are then used as replacement of OPS in various percentages in M40 concrete and compressive strength, split tensile strength and flexural strength characteristics are studied.*
***Findings:** It has been found that the replacement of cement in M40 concrete by adding 30% of OPS results in high strength increase by 8.5MPa for 28 days strength*
***Conclusion/Improvements:** This composite material reduces the cost of construction and act as light weight concrete. There is an abundant scope for the use of this LWA in various construction and development activities*

***Keywords:** Light weight Aggregate, Flexural strength, compressive strength, Split Tensile strength.*

INTRODUCTION

Concrete is the most popular construction materials used since hundred years ago. Because of its flexibility in usage it becomes more important and is preferred compared to timber or steel. The combination of cement, coarse aggregate and water makes up a concrete. It is acceptable fact now that not only the strength of concrete which plays a main role, in deciding the quality of concrete but what that matters most is the durability at services stages.

The growing concern of resources depletion and global pollution has challenged many engineers to seek and develop new materials relying on renewable resources.[1,2,6] Many of these new materials are used as aggregate for the production of lightweight concrete. The high demand for concrete in construction industry has resulted to a rapid decrease in natural stone deposit such as the Gravel and Granite which leads to usage of natural stone deposit and caused a need to find alternate material for the replacement.[4]

There are other classes of non-structural lightweight concrete with lower density made with other aggregate materials and higher air voids in the cement paste matrix, such as in cellular concrete used for their insulation properties.

Lightweight aggregate originate from either

- Natural materials, like volcanic pumice.
- The thermal treatment of natural raw materials like clay, slate or shale i.e. Leca.
- Manufacture from industrial by-products such as fly ash, i.e. Lytag.
- Processing of information by-products like FBA or slag.

Benefits of using lightweight concrete:

- Reduction in dead loads making saving in foundations and reinforcement. Improved thermal properties.
- Improved fire resistance.
- Savings in transporting and handling precast units on site.
- Reduction in framework and propping.

METHODOLOGY

Methodology involve for entire project work

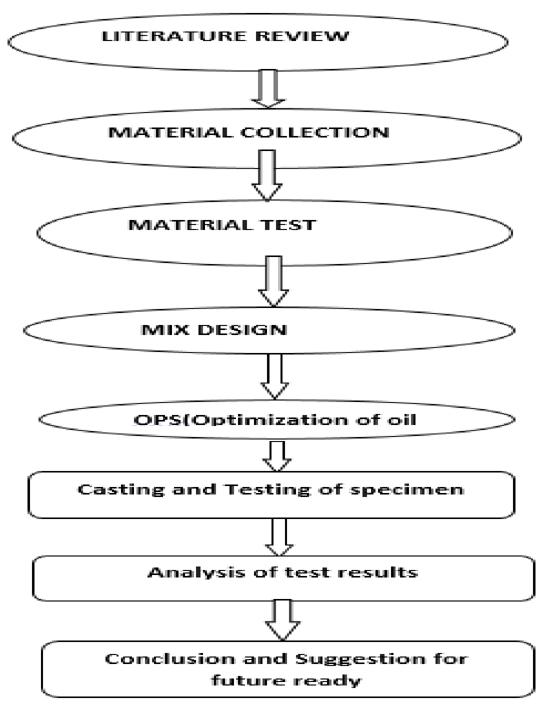

Fig 1. Methodology chart

Materials Used:

PROPERTIES	VALUES OBTAINED	REQUIRMENTS AS PER IS12269-1987
Lime saturation factor	0.9	0.8-1.02
Alumina Modulus	1.23	0.66(min)
Insoluble residue (%)	0.25	4(max)
Magnesia (%)	1.1	6(max)
Sulphuric anyhydrideSO_3 (%)	1.5	3(max)
Loss of ignition (%)	0.8	4(max)
Alkalis	-	-
Chloride (%)	0.002	0.1(max)
C_3A Content	7	-
Temperature during Testing	27±2	27±2
Humidity (%)	65±5	65±5

Table 1: Chemical composition of OPC

Fine Aggregate

“Fine aggregate” is defined as material that will pass through 4.75mm sieve and will, for the most part, be retained on a 75μ sieve.

For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. Aggregates are the major ingredients of concrete, as they constitute 70-75% of the volume, provide a rigid skeleton structure for concrete and act as economical space fillers. In India river sand is used as fine aggregate. The sand was washed and screened tested as per the procedure given in IS: 2386-1963.[9]

Coarse Aggregate : Coarse aggregate consists of river gravel, crushed stone or manufactured aggregate with particle size equal to or greater than4.75mm. It shall comply with the requirements of IS:383-1970.[7] In this coarse aggregate of maximum size 20mm was used and the physical properties are as follows,

PHYSICAL PROPERTIES OF COARSE AGGREGATE

Properties	Values Obtained	Requirments as per IS:383-1970
Specific gravity	2.74	2.6-2.9
Crushing Strength%	2.57	Should not exceed 30%
Water Absorption %	1.25	Not more than 2%
Impact Strength %	6.25	Should not exceed 30%
Abrasion Value%	4.05	Should not exceed 30%

Table 2: Physical Properties of Coarse Aggregates

Oil Palm Shell (OPS)

Oil palm Shell is the end product of oil palm manufacturing process. OPS is approximately 60% lighter compared to the conventional crushed stone aggregates. The resulting concrete will be light weight. Lightweight concrete using OPS as coarse aggregate is still a relatively new construction material. Physical properties of OPS given as per the IS:383-1970 and ASTM C330-1999.[7,8,9,10,11]

Physical Properties of OPS

Properties	Values
Specific gravity	1.17
Bulk Unit Weight, kg/m^3	50-600
Fitness modulus	6.08
Los Angeles abrasion value,%	4.90
Aggregate impact value,%	7.51
Aggregate crushing value,%	8.00
24-water absorption,%	2.93

Table 3: Physical Properties of OPS

Water

Water is needed for the purpose of hydration of cement and to provide workability during mixing and placing of concrete. For this study portable water available with the Ph value 7 and conforming to the specifications of IS: 456-2000 is used for concreting as well as curing of the specimens.

TEST ON MATERIALS:

Scope and Objectives

The objective of the test is to determine the specific gravity of fine aggregate passing through 4075mm IS sieve by pycnometer.

Material and Equipment:

- Pycnometer with conical brass cap
- Electronic balance

Test Procedure:

1. The pycnometer was cleaned and dried. The cap was screwed tight and its mass (M_1) is taken
2. A sample of oven dried soil placed in the pycnometer and the mass is taken as(M_2).
3. The bottle is then filled with water gradually removing the entrapped air by shaking the bottle. The mass(M_3) of the bottle, soil and water is taken.

4. Finally the bottle is emptied completely and thoroughly washed, and clean water is filled to the mass (M_4) taken.

CALCULATION:

The specific gravity is determined using the relation:

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

Where,

M_1=mass of empty pycnometer

M_2=mass of pycnometer and dry soil

M_3= mass of pycnometer and soil and water

M_4=mass of pycnometer filled with water only

G= Specific gravity of soils.

Sieve Analysis for fine aggregate

The percentage of various size of particles in the soil can be determined by sieve analysis. The analysis is the true representative of grain size distribution, since the test is not affected by temperature, etc.

Scope and objectives:

The objective of the test is to determine the fitness modulus and grain size distribution of fine aggregate by sieving.

Test Procedure:

i. The soil sample is taken from the field and dried in oven.
ii. The sample is placed in a container and sufficient water is poured to cover it.
iii. Puddle the sample thoroughly in water and transfer the slurry into 75µ sieve and keep them in the oven.
iv. Sieve the dried material retained on the 75µ sieve, through the following set of sieves: 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150 µ , 75 µ.The set of sieves should be arranged one above the other and fitted to a mechanical sieve shaker such that 4075mm sieve as at the top and the pan can be placed below the 75µ sieve.
v. A minimum of 10 min sieving is done and the soil fraction retained on each sieve is collected and the mass of each fraction is determined.
vi. The percentage of soil retained on each sieve is calculated on the basis of total mass of soil sample taken and from these results the percent passing through each sieve is calculated.

Tabulation and observation of sieve analysis

Sieve of sieve(mm)	Weight of soil retained(kg)	% weight retained	Cummulative % retained	%Finer
4.75	0.065	6.5	6.5	93.5
2.36	0.115	11.25	18	82
1.18	0.21	21	39	61
0.60	0.475	47.5	86.5	13.5
0.30	0.1	10	96.5	3.5
0.15	0.01	1	97.5	2.5
∑ cummulative percentage retained			256	

Table 4: Results for sieve analysis

Calculation:

Fineness modulus of fine aggregate =(cumulative % retained)/100
=256/100
=2.56

Fineness Modulus of Fine Aggregate=2.56

Bulk Density Test For Fine Aggregate

Bulk density is defined as the total mass per unit volume of material. It is expressed in terms of g/cm^3.

Scope and Objective:

The objective of the test is to determine the bulk density of fine aggregate by sand replacement method.

Test Procedure:

I. Fill the sand in the sand pouring cylinder upto height of 1cm below the top.
II. Determine the total initial mass of the cylinder+sand(M_3).
III. Allow the sand to run out by opening the shutter. Close the value when no further movement of sand is observed. The mass of the cylinder+ the sand remaining in it after filling the cone is taken as(M_2).
IV. Then place the sand pouring cylinder concentrically on top of the calibrating cylinder. Open the shutter and permit the sand to run into the container. When no further movement of sand is seen, close the shutter. Measure the weight of the sand pouring cylinder +the sand remaining in it after filling the calibrating cylinder and cone as(M_3).
V. Determine the volume of the calibrating cylinder.

Observation and calculation:

Weight of empty sand pouring cylinder =10.45kg
Weight of cylinder+sand =26.95kg
Weight of cylinder+weight of sand after filling the cone =25.16kg
Weight of calibrating cylinder =5.07kg
Weight of cylinder+weight of sand after filling calibrating cylinder+cone =16.96kg
Volume of calibrating cylinder =12870cm^3
Bulk density, =W/V
=16.96/12870
=1317kg/m^3

Bulk Density Test for fine Aggregate=1317kg/m³

Test on coarse aggregate

Water absorption Test for coarse aggregate

Scope and objectives:

The objective of the test is to determine the percentage of water adsorption of coarse aggregate.

Test procedure:

1. Take about 2 kg of aggregate retained on 10mm sieve.
2. Weight the sample and it is recorded as(W_1).
3. Immerse the sample in water for 24 hrs at a temperature of 22◦C to 32◦C.
4. Dry the vessel from outside and place the aggregate on dry cloth. Gently dry it and leave exposed to the atmosphere for not less than 10 min.
5. Weigh the aggregate now and record it as(W_3)
6. Place the aggregate in oven and leave it for 24 hrs at a temperature of 100 to 110◦C.
7. After that allow the aggregate to cool and record its weight (w_3)

Observation and calculation :
Weight of aggregate($\boldsymbol{w_1}$) =2kg
Weight of saturated surface by sample (W_2) =2.12kg
Weight of oven dry sample(W_3) =2.095kg
%water absorption = $(W_2 - W_1)/ W_3$*100 =1.19%

Water absorption of coarse aggregate =1.19%

Impact value for coarse aggregate

Scope and objective:

The objective of the test is to determine the impact value of coarse aggregate.

Materials and equipment:

- Cylindrical measures
- Tamping rod
- Impact testing machine
- Electronic balance

Test procedure:

- Fill about 1/3 of the cylindrical measure with aggregate passing through 12.5 mm sieve and retained on 10mm sieve and tamp the aggregate with 25 strokes.
- Repeat the procedure twice for the remaining 2/3 portion. Note down the weight of the sample.
- Place the cylinder in its position in the impact testing machine.
- Allow the load to fall 15 times at one blow per second at constant rate.
- Take the sample out of the cylinder carefully and sieve it on 2.36mm sieve. Weigh the portion passing through 2.36mm sieve.
- Calculate the aggregate impact value[7].

Observation and calculation:

Weight of empty cup	=1.755kg
Weight of empty cup + aggregate	=2.315kg
Weigh of aggregate(A)	=0.560kg
Weigh of aggregate passing through 2.36mm sieve(B)	=0.035kg
Aggregate impact value	=B/A*100
	=6.25%

Aggregate impact value=6.25%

TESTS ON LIGHTWEIGHT AGGREGATE (OPS)

Water absorption test for lightweight aggregate: The water absorption tests for OPS is same as for coarse aggregate and the value obtained is 2.93%

Impact value for lightweight aggregate:The impact value tests for OPS is same as for coarse aggregate and the value obtained is 7.51%

MIX DESIGN

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining the relative proportions with the objective of producing concrete of certain minimum strength and durability as economically as possible.[8]

Mix design for M40 grade concrete:

Grade designation-M40

Type of cement	– OPC 43 grade conforming to IS 8112
Maximum nominal size of the aggregate	- 20 mm (angular)
Minimum water cement ratio	-0.12(IS 456- 2000)
Workability	- 100mm(slump)
Exposure condition	–Severe
Maximum cement content	- 320kg/m^3 (IS 456)

ResultofMaterials

Specific gravity of cement	-3.15
Specific gravity of fine aggregate	-2.74
Specific gravity of coarse aggregate	-2.74

Target strength for mix propotions:

Calculation of Mix

a. Volume of concrete =1m^3

b. Volume of cement = (mass of cement / specific gravity of cement
=(492.5/3.15) x (1/1000)=0.197m^3

c. Volume of water = (mass of water/ specific gravity of water) x (1/1000)
=(197/1) x (1/1000)=0.197m^3

c. Volume of air in aggregate =[a-(b+c)]
=[1-(0.156+0.197)] =0.647m^3

d. Mass of coarse aggregate =d x Volume of coarse aggregate x specific gravity of coarse aggregate x 1000
=0.647 x 0.56 x 2.74 x 1000
= 993 kg

e. Mass of fine aggregate =d x Volume of fine aggregate x specific gravity x 1000
=0.647 x 0.44 x 2.74 x 1000 =780 kg

Mix proportion for M40 grade concrete

Cement	=	492.5 kg/m^3
Water	=	197 litres
Fine aggregate	=	780 kg/m^3
Coarse aggregate	=	993 kg/ m^3
Water cement ratio	=	0.4

MIX PROPORTIONS =1:1.58:2.02

Calculation for cube

Volume of cube	= 0.15*0.15*0.15
	= 3.375*$10^{-3}m^3$*1800
	= 6.075*1.2
	= 7.29kg
Cement	= (1/4.6)*7.29
	= 1.598kg
Fine aggregate	= (1.58/4.6)*7.29
	= 2.53kg
Coarse aggregate	= (2.02/4.6)*7.29
	= 3.23kg

Calculation for prism

Volume of prism	= 0.5*0.1*0.1m*1800*1.2
	= 10.8kg
Cement	= (1/4.6)*10.8
	= 2.36kg
Fine aggregate	= (1.58/4.6)*10.8
	= 3.74kg
Coarse aggregate	= (2.02/4.6)*10.8
	= 4.78kg

Calculation for cylinder

Volume of cylinder	=5.3*10^{-3}*1800*1.2
	=11.45kg
Cement	= (1/4.6)*11.45
	=2.51kg
Fine aggregate	=(1.58/4.6)*11.45
	=3.97kg
Coarse aggregate	= (2.02/4.6)*10.8
	=5.07kg

MIX COMBINATION

Table 5 Mix Combination and OPS %

S.no	Mix combination	OPS(%)
1	OPS0	0
2	OPS10	10
3	OPS20	20
4	OPS30	30
5	OPS40	40
6	OPS50	50

MIX PROPOTIONS
Table 6: Mix proportions of OPS

S.NO.	Replacement of OPS in %	Corresponding mix proportion
1	0	1:1.58:2.02
2	10	1:1.58:1.82
3	20	1:1.58:1.62
4	30	1:1.58:1.41
5	40	1:1.58:1.21
6	50	1:1.58:1.01

Experimental investigation:

PREPARATION OF SPECIMEN :

The quantities of the constituents of the concrete were obtained from the Indian Standard Mix Design method (IS: 10262-2009)[8]. The strength characteristics of M40 grade of concrete cured were studied by casting samples cubes, cylinder and prism. The cement, fine aggregate and coarse aggregate were collected and mixed to appropriate proportion. Mould of interior dimensions (150 * 150 * 150 mm) for cube (150 mm dia * 300 mm height) for cylinder and (500 * 100 * 100) for prisms were taken. Meanwhile the mould are screwed tightly to avoid leakage; oil was applied on inner surface of the moulds. The concrete after mixing was poured into mould layer by compacting with a tamping rod. The number of each specimen casted for M40 grade are given in table.

CURING OF SPECIMENS : Demoulding was done after 24 hrs and the specimens were cured under water. After 28 days, the cube, cylinder and prism specimens were removed from tank and taken for testing.

TESTING OF SPECIMENS: After curing the specimens were left for drying and then tested for determining the strength.

COMPRESSIVE STRENGTH TEST:

Cube specimens of size 150 mm * 150 mm * 150 mm were cast for each mix proportion. After curing for required period the specimens were tested using compressive testing machine. The load was applied without shock and increased continuously at a rate of approximately 140 $kg/cm^2/min$ until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load taken by specimen was recorded.

Compressive strength is determined using the formula

Compressive strength (MPa) = Maximum load (N)/cross sectional area (mm^2) [9]

SPLIT TENSILE STRENGTH TEST:

Cylindrical specimens of diameter 150 mm and length 300 mm were cast for required mix proportion.

Split tensile strength (MPa) = $2P/\pi LD$

Where, P is the compressive load on the cylinder

FLEXTURAL STRENGTH TEST:

Prism of size 500 mm * 100 mm * 100 mm were casted for required mix proportion[7]. After curing for required period the specimens were tested. The specimen was supported and the distance between the supports was 400 mm. The load was that is, spaced at 200 mm centre to centre. The load was divided equally between the two loading rollers, and all the rollers were mounted in such a manner that the load was applied axially without any torsional stress or restrains on the specimens.

Modulus of rupture, $fB = PL/bd^2$

RESULTS AND DISCUSSION:

Compressive strength for M40 grade concrete at 28 days of curing

S.NO	% of OPS	Compressive strength
1	0	42.67
2	10	42.98
3	20	43.10
4	30	43.61
5	40	41.89
6	50	42.67

Table 7: Compressive Strength of OPS Results

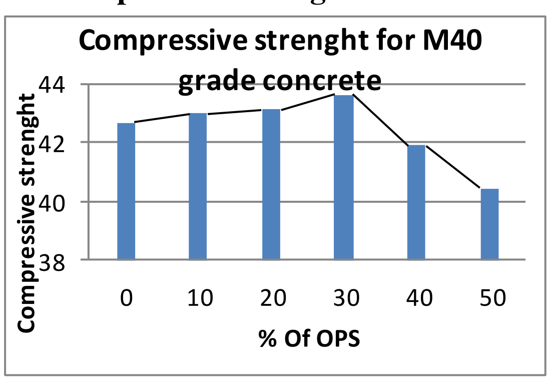

Figure 2: % OPS Vs Compressive Strength

Split Tensile strength for M40 grade concrete at 28 days of curing

S.NO.	% OF OPS	Split tensile strength (N/mm^2)
1	0	4.45
2	10	4.52
3	20	4.62
4	30	4.78
5	40	3.93
6	50	3.23

Table 8: Results of Split Tensile Test

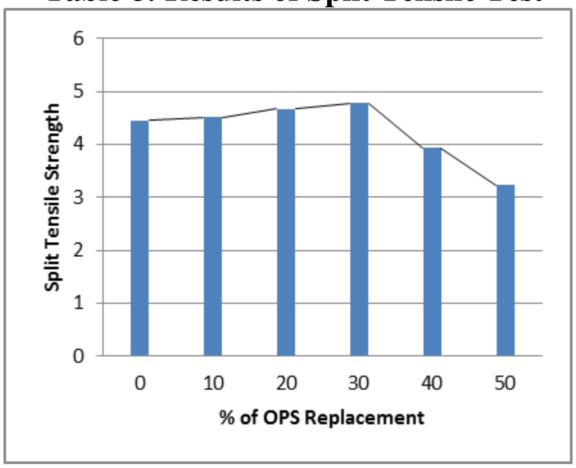

Fig 3: % of OPS and Split Tensile Strength

Flexural strength for M40 grade concrete at 28 days of curing:

S.NO.	% OF OPS	Flexural Strength (N/mm^2)
1	0	3.89
2	10	3.95
3	20	4.02
4	30	4.11
5	40	3.8
6	50	3.73

Table 9:Results of Flexural Strength Test

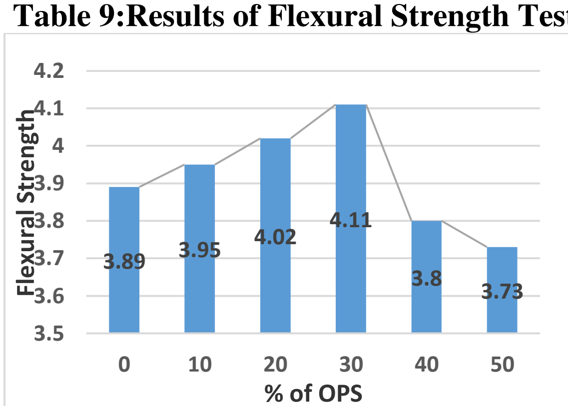

Fig 4 . % of OPS Vs Flexural Strength

Density of Specimen (kg/m^3)

% of OPS	After 28 days of curing
0	2442
10	1837
20	1782
30	1717
40	1649
50	1579

Table 10: Density of Specimen

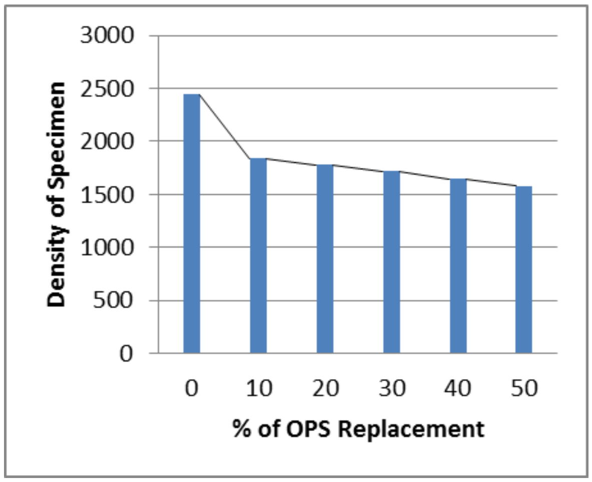

Fig 5: % of OPS Vs Density curve

CONCLUSION

1. The compressive strength of the specimens of grade M40 cured for 28 days is increased by 0.72% , 1.07% , 2.20% upto 30% replacement of OPS respectively.
2. The compressive strength of the specimens of grade M40 cured for 28 days is decreased by 1.82% , 5.25% for 40 and 50% replacement of OPS respectively.
3. The Split Tensile Strength of the specimens of grade M40 cured for 28 days is increased by 1.5% , 4.9% , 7.4% upto 30% replacement of OPS respectively.
4. The Split Tensile Strength of the specimens of grade M40 cured for 28 days is decreased by 11.6% and 27% for 40 and 50% replacement of OPS respectively.
5. The Flexural Strength of the specimens of grade M40 cured for 28 days is increased by 1.54% , 3.34% , 5.65% upto 30% replacement of OPS respectively.
6. The Flexural Strength of the specimens of grade M40 cured for 28 days is decreased by 2.31% , 4.11% for 40 and 50% replacement of OPS respectively
7. The range of densities for OPS concrete for 28 days was between 2442 - 1579 kg/m^3
8. The maximum value is attained at 30% in all the test results and hence it is recommended for usage

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