

Date : October 11, 2025
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 minutes (prior to writing time)

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is provided to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
 - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
 Part II - 4 Short Answer Questions

All questions under SECTION A are COMPULSORY.
 - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **13 printed pages**, including this instruction page.

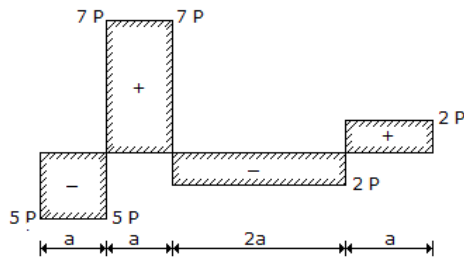
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Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. In a suspension bridge, the main cables are subjected to
 - a) Bending
 - b) Shear
 - c) Compression
 - d) Tension
2. In reinforce concrete, the primary purpose of stirrups is to
 - a) Resist axial tension
 - b) Prevent shrinkage cracks
 - c) Hold the bars in place
 - d) Resist shear
3. The bearing capacity of a footing is maximum when
 - a) Water table is at surface
 - b) Water table is at footing base
 - c) Water table is below the footing
 - d) Soil is fully saturated
4. The efficiency of a sedimentation tank increases with
 - a) Increase in depth
 - b) Increase in detention time
 - c) Decrease in surface area
 - d) Increase in inflow rate
5. Float in CPM indicates
 - a) Leeway in activity start or finish
 - b) Unused budget
 - c) Delay in materials
 - d) Time saved
6. A cantilever beam carries maximum bending moment at
 - a) Free end
 - b) Midpoint
 - c) Fixed support
 - d) Anywhere along span
7. In RCC beams, the main reinforcement is provided to resist
 - a) Torsion
 - b) Shear
 - c) Bending tension
 - d) Axial compression

8. Liquid limit of soil is determined using
 - a) Proctor test
 - b) Casagrande apparatus
 - c) Core cutter
 - d) Sand replacement method
9. The shape of STOP signboard is
 - a) Circular
 - b) Triangular
 - c) Rectangular
 - d) Octagonal
10. The unit of measurement for brickwork in cement mortar is
 - a) Square meter
 - b) Cubic meter
 - c) Running meter
 - d) Kilogram
11. The rate analysis is done primarily to determine
 - a) Estimated cost per unit work
 - b) Quantity of materials
 - c) Labour charges
 - d) Market price
12. For the same cross-sectional area which has the highest moment of inertia?
 - a) Square
 - b) Circle
 - c) Hollow circle
 - d) I-section
13. Which one of the following tests is a non-destructive test for concrete?
 - a) Slump test
 - b) Rebound hammer test
 - c) Compression test
 - d) Flexural test
14. What type of curve is used to connect two roads with different alignments?
 - a) Simple curve
 - b) Compound curve
 - c) Transition curve
 - d) Reverse curve
15. Plastic hinge is formed when

- a) The moment reaches plastic moment
 - b) The section cracks
 - c) The structure yields
 - d) Elastic limit is reached
16. The quantity of cement required for 1m³ of 1:2:4 concrete (by volume, wet mix) is approximately
- a) 200 Kg
 - b) 250 Kg
 - c) 300 Kg
 - d) 400 Kg
17. Prestressing in concrete is done to
- a) Increase deflection
 - b) Reduce tensile strength
 - c) To increase the weight of structures
 - d) Introduce compressive stresses
18. Back sight is taken on
- a) Staff at turning point
 - b) Bench mark
 - c) Foresight station
 - d) Next point
19. Which is the correct sequence of treatment in a typical water treatment plant?
- a) Screening----Coagulation---Sedimentation---Filtration
 - b) Filtration----Coagulation-----Sedimentation-----Screening
 - c) Coagulation-----Filtration-----Sedimentation-----Disinfection
 - d) Sedimentation-----Screening-----Filtration-----Disinfection
20. For maximum deflection in a simply supported beam carrying a UDL, the point of contraflexure occurs at
- a) Centre
 - b) Quarter span
 - c) At the support
 - d) There is no point of contraflexure
21. A cantilever beam with a point load at free end deflects by $\delta = \frac{WL^3}{3EI}$ what happens to deflection if span L is doubled?
- a) Become 8x
 - b) Becomes 4x
 - c) Tripled
 - d) Doubled
22. The shear force diagram of a beam is shown in the given figure. The absolute bending moment in the beam is



- a) $2P \times a$
- b) $5P \times a$
- c) $4P \times a$
- d) $7P \times a$

23. Unit hydrograph represents runoff from

- a) 1mm rainfall
- b) 1cm rainfall
- c) Peak flood only
- d) Total rainfall

24. Weepholes in retaining wall help reduce

- a) Hydrostatic pressure
- b) Flank pressure
- c) Bearing pressure
- d) Overturning moment

25. Curtailment of reinforcement in RCC beams is done when

- a) Shear is maximum
- b) Bending moment reduces
- c) Depth is constant
- d) Load is variable

26. In passive earth pressure, the soil must

- a) Be completely dry
- b) Move away from wall
- c) Move towards wall
- d) Have zero cohesion

27. For a fluid flowing in pipe, the continuity equation is based on

- a) Newton's second law
- b) Conservation of mass
- c) Conservation of energy
- d) Pascal's law

28. Soils having more than 50% passing through 75-microm sieve is classified as

- a) Coarse soil
- b) Fine soil
- c) Organic soil
- d) Gravel

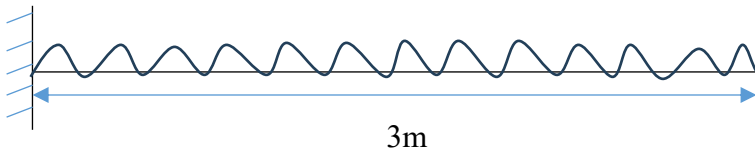
29. The admixture used to increase setting time of concrete is

- a) Retarder
 - b) Accelerator
 - c) Plasticizer
 - d) Superplasticizer
30. Which of the following methods is used to measure earthwork volume calculation in irregular terrain?
- a) Mid-section method
 - b) End area method
 - c) Cross section method
 - d) Prismoidal formula

PART II: Short Answer Questions (20 marks)

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

1. Describe the purpose of a bar bending schedule (BBS). What information does it contain? Provide a sample of BBS for a column reinforcement in a building drawing. **(5 marks)**
2. Design a cantilever rectangular beam of span 3m and carrying a characteristic UDL of 20 kN/m. Assume that sufficient safety against overturning is there and reinforcement anchorages are also available. Use M20 grade of concrete and HYSD reinforcement of grade Fe 415. Draw SFD and BMD including area of reinforcement required to resist the moment. **(5 marks)**



3. What is the role of bracing in steel structures? Briefly explain its purpose and mention two commonly used types of bracing. **(5 marks)**
4. What is meant by batching of concrete? Explain the different types of batching and discuss their significance in concrete production. Which method is generally recommended, and why? **(5 marks)**

SECTION B: CASE STUDY (50 marks)

Choose either CASE I or CASE II from this section. Each case study carries 50 marks. Marks for each sub-questions is indicated in the brackets.

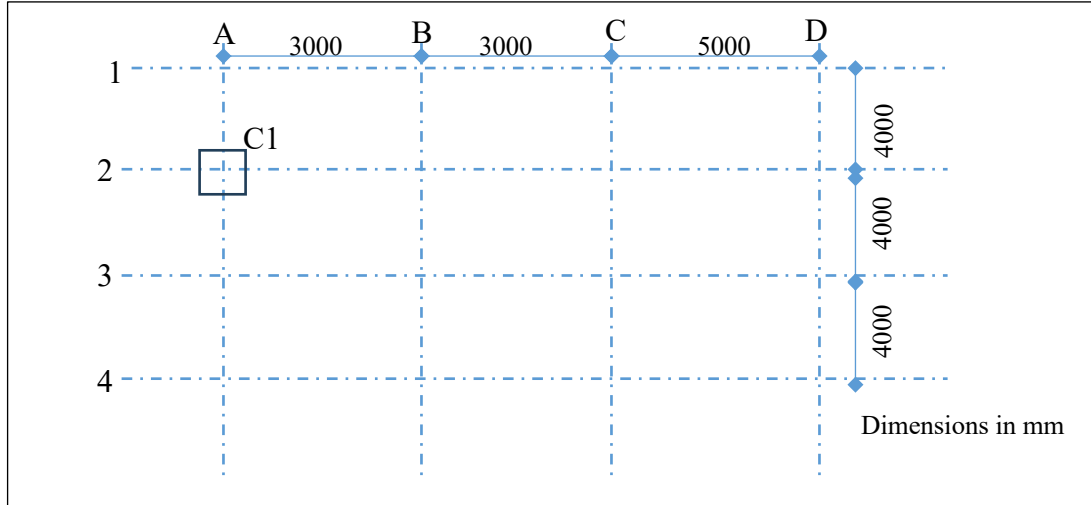
CASE I

1. You have been appointed as a Designer in the Design Division for Infrastructure Development. Your first assignment is to design an Office Building for the Regional Office for Infrastructure Development (RoID) at Mongar. As the final step in your building design, you are required to design an **isolated footing** to support a building column (**Column C1**) subjected to an axial load. The footing must be designed in accordance with IS 456:2000.

Use the following design parameters and refer to the attached IS code for guidance.

Sl. No	Parameter	Value
1.	Column Size	300x300 mm
2.	Axial service load on column	1000 kN
3.	Dead load of Footing	10% of Column load

4.	Safe Bearing Capacity of Soil	150 kN/m ²
5.	Concrete Grade	M25
6.	Steel Grade	Fe500
7.	Unit Weight of Concrete	25 kN/m ³
8.	Depth of Foundation below Ground Level	1500mm



- Determine the required area of footing and check for net upward pressure. **(10 Marks)**
 - Determine the area of steel required and prepare a sketch for reinforcement detailing. **(15 Marks)**
 - Check for one way shear and Design Bearing Pressure. **(10 Marks)**
- What key features will you incorporate in the structural design of a building to make them earthquake-resistant in Bhutan, Seismic Zone V? Mention at least three structural provisions in accordance with IS 1893 and IS 4326. **(5 Marks)**
 - For a project with the following characteristics, construct a PERT network. Find the Critical Path and Variance for each event. **(10 Marks)**

Activity	Most optimistic time (a)	Most pessimistic time (b)	Most likely time (m)
(1-2)	1	5	1.5
(2-3)	1	3	2
(2-4)	1	5	3
(3-5)	3	5	4
(4-5)	2	4	3
(4-6)	3	7	5
(5-7)	4	6	5
(6-7)	6	8	7
(7-8)	2	6	4
(7-9)	5	8	6
(8-10)	1	3	2
(9-10)	3	7	5

CASE II

1. As a part of your first assignment in office you are asked to visit a site for a road widening project along Mongar-Lhuentse Secondary National Highway. During the visit there is a need for a construction of retaining wall to retain the cut slope. Design a retaining wall with the following details and assume wall geometry as per the design:

Sl. No	Parameter	Value
1.	Height of Wall (H)	3.0m
2.	Density of Backfill (γ)	18kN/m ³
3.	Angle of internal friction (ϕ)	30°
4.	Cohesion (c)	0 (Granular Soil)
5.	Angle of wall friction (δ)	20°
6.	Bearing capacity of Soil	200 kN/m ²
7.	Masonry Density	22 kN/m ³
8.	Coefficient of Friction (μ)	0.6

- What type of retaining wall will you propose for this Design? List any other four types of retaining wall with rough sketch? **(10 Marks)**
 - Design the proposed wall and check against Overturning, Sliding and Bearing Pressure. **(10 Marks)**
 - Sketch a rough drawing with dimensions of the proposed design to be implemented at site. **(10 Marks)**
2. The ordinates of 6-hour unit hydrograph are tabulated below. Derive 12-hour unit hydrograph of the same unit volume as of the 6-hour unit hydrograph. **(10 Marks)**

Time (Hrs)	6-hour Unit Hydrograph ordinates (m/s)
0	0
3	200
6	500
9	1000
12	1600
15	2400
18	3500
21	4200
24	5200
27	4400
30	3100
33	2300
36	1500
39	1000
42	650
45	400
48	250
51	150
54	0

3. Differentiate between flexible and rigid pavements based on structural behaviour and layers. Draw a cross section of both pavement types. **(10 Marks)**

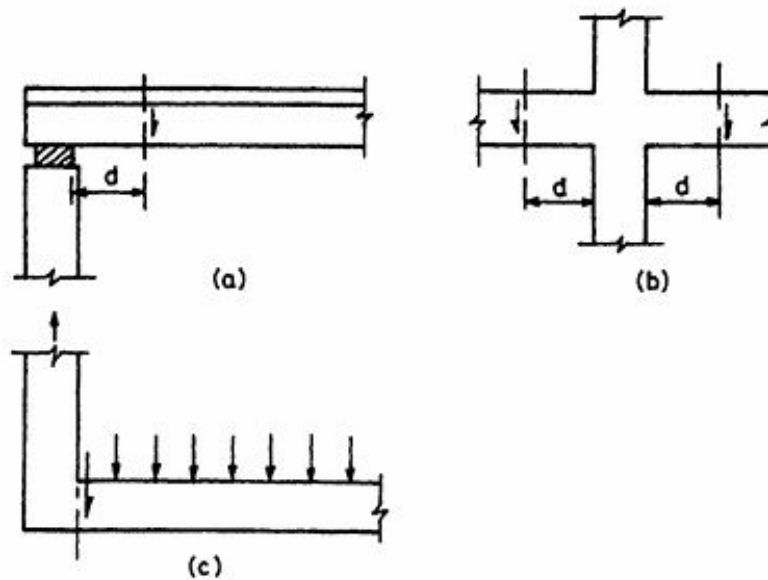


FIG. 2 TYPICAL SUPPORT CONDITIONS FOR LOCATING FACTORED SHEAR FORCE

but in no case greater than the breadth of the web plus half the sum of the clear distances to the adjacent beams on either side.

- For T-beams, $b_f = \frac{l_o}{6} + b_w + 6 D_f$
- For L-beams, $b_f = \frac{l_o}{12} + b_w + 3 D_f$
- For isolated beams, the effective flange width shall be obtained as below but in no case greater than the actual width:

$$\text{T-beam, } b_f = \frac{l_o}{\left(\frac{l_o}{b}\right) + 4} + b_w$$

$$\text{L-beam, } b_f = \frac{0.5 l_o}{\left(\frac{l_o}{b}\right) + 4} + b_w$$

where

- b_f = effective width of flange,
- l_o = distance between points of zero moments in the beam,
- b_w = breadth of the web,
- D_f = thickness of flange, and
- b = actual width of the flange.

NOTE — For continuous beams and frames, ' l_o ' may be assumed as 0.7 times the effective span.

23.2 Control of Deflection

The deflection of a structure or part thereof shall not adversely affect the appearance or efficiency of the

structure or finishes or partitions. The deflection shall generally be limited to the following:

- The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the supports of floors, roofs and all other horizontal members, should not normally exceed span/250.
- The deflection including the effects of temperature, creep and shrinkage occurring after erection of partitions and the application of finishes should not normally exceed span/350 or 20 mm whichever is less.

23.2.1 The vertical deflection limits may generally be assumed to be satisfied provided that the span to depth ratios are not greater than the values obtained as below:

- Basic values of span to effective depth ratios for spans up to 10 m:

Cantilever	7
Simply supported	20
Continuous	26

- For spans above 10 m, the values in (a) may be multiplied by 10/span in metres, except for cantilever in which case deflection calculations should be made.
- Depending on the area and the stress of steel for tension reinforcement, the values in (a) or (b) shall be modified by multiplying with the modification factor obtained as per Fig. 4.
- Depending on the area of compression reinforcement, the value of span to depth ratio be further modified by multiplying with the modification factor obtained as per Fig. 5.

cross-section in compression shall be limited by the area above the neutral plane, and the angle of slope or depth and location of steps shall be such that the design requirements are satisfied at every section. Sloped and stepped footings that are designed as a unit shall be constructed to assure action as a unit.

34.1.2 Thickness at the Edge of Footing

In reinforced and plain concrete footings, the thickness at the edge shall be not less than 150 mm for footings on soils, nor less than 300 mm above the tops of piles for footings on piles.

34.1.3 In the case of plain concrete pedestals, the angle between the plane passing through the bottom edge of the pedestal and the corresponding junction edge of the column with pedestal and the horizontal plane (see Fig. 20) shall be governed by the expression:

$$\tan \alpha \leq 0.9 \sqrt{\frac{100 q_n}{f_{ck}} + 1}$$

where

q_n = calculated maximum bearing pressure at the base of the pedestal in N/mm^2 , and

f_{ck} = characteristic strength of concrete at 28 days in N/mm^2 .

34.2 Moments and Forces

34.2.1 In the case of footings on piles, computation for moments and shears may be based on the assumption that the reaction from any pile is concentrated at the centre of the pile.

34.2.2 For the purpose of computing stresses in footings which support a round or octagonal concrete column or pedestal, the face of the column or pedestal shall be taken as the side of a square inscribed within the perimeter of the round or octagonal column or pedestal.

34.2.3 Bending Moment

34.2.3.1 The bending moment at any section shall be determined by passing through the section a vertical

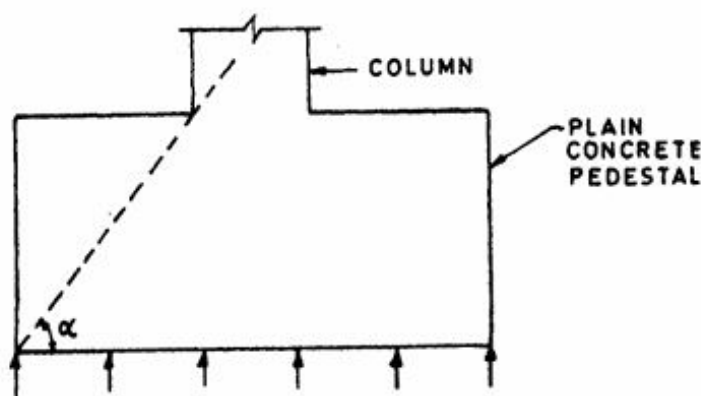


FIG. 20

plane which extends completely across the footing, and computing the moment of the forces acting over the entire area of the footing on one side of the said plane.

34.2.3.2 The greatest bending moment to be used in the design of an isolated concrete footing which supports a column, pedestal or wall, shall be the moment computed in the manner prescribed in 34.2.3.1 at sections located as follows:

- At the face of the column, pedestal or wall, for footings supporting a concrete column, pedestal or wall;
- Halfway between the centre-line and the edge of the wall, for footings under masonry walls; and
- Halfway between the face of the column or pedestal and the edge of the gusseted base, for footings under gusseted bases.

34.2.4 Shear and Bond

34.2.4.1 The shear strength of footings is governed by the more severe of the following two conditions:

- The footing acting essentially as a wide beam, with a potential diagonal crack extending in a plane across the entire width; the critical section for this condition shall be assumed as a vertical section located from the face of the column, pedestal or wall at a distance equal to the effective depth of footing for footings on piles.
- Two-way action of the footing, with potential diagonal cracking along the surface of truncated cone or pyramid around the concentrated load; in this case, the footing shall be designed for shear in accordance with appropriate provisions specified in 31.6.

34.2.4.2 In computing the external shear or any section through a footing supported on piles, the entire reaction from any pile of diameter D_p whose centre is located $D_p/2$ or more outside the section shall be assumed as producing shear on the section; the reaction from any pile whose centre is located $D_p/2$ or more inside the section shall be assumed as producing no shear on the section. For intermediate positions of the pile centre, the portion of the pile reaction to be assumed as producing shear on the section shall be based on straight line interpolation between full value at $D_p/2$ outside the section and zero value at $D_p/2$ inside the section.

34.2.4.3 The critical section for checking the development length in a footing shall be assumed at the same planes as those described for bending moment in 34.2.3 and also at all other vertical planes where abrupt changes of section occur. If reinforcement is curtailed, the anchorage requirements shall be checked in accordance with 26.2.3.

34.3 Tensile Reinforcement

The total tensile reinforcement at any section shall provide a moment of resistance at least equal to the bending moment on the section calculated in accordance with 34.2.3.

34.3.1 Total tensile reinforcement shall be distributed across the corresponding resisting section as given below:

- In one-way reinforced footing, the reinforcement extending in each direction shall be distributed uniformly across the full width of the footing;
- In two-way reinforced square footing, the reinforcement extending in each direction shall be distributed uniformly across the full width of the footing; and
- In two-way reinforced rectangular footing, the reinforcement in the long direction shall be distributed uniformly across the full width of the footing. For reinforcement in the short direction, a central band equal to the width of the footing shall be marked along the length of the footing and portion of the reinforcement determined in accordance with the equation given below shall be uniformly distributed across the central band:

$$\frac{\text{Reinforcement in central band width}}{\text{Total reinforcement in short direction}} = \frac{2}{\beta + 1}$$

where β is the ratio of the long side to the short side of the footing. The remainder of the reinforcement shall be uniformly distributed in the outer portions of the footing.

34.4 Transfer of Load at the Base of Column

The compressive stress in concrete at the base of a column or pedestal shall be considered as being transferred by bearing to the top of the supporting pedestal or footing. The bearing pressure on the loaded area shall not exceed the permissible bearing stress in direct compression multiplied by a value equal to

$$\sqrt{\frac{A_1}{A_2}} \text{ but not greater than } 2;$$

where

A_1 = supporting area for bearing of footing, which in sloped or stepped footing may be taken as the area of the lower base of the largest frustum of a pyramid or cone contained wholly within the footing and having for its upper base, the area actually loaded and having side slope of one vertical to two horizontal; and

A_2 = loaded area at the column base.

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For working stress method of design the permissible bearing stress on full area of concrete shall be taken as $0.25 f_{ck}$; for limit state method of design the permissible bearing stress shall be $0.45 f_{ck}$.

34.4.1 Where the permissible bearing stress on the concrete in the supporting or supported member would be exceeded, reinforcement shall be provided for developing the excess force, either by extending the longitudinal bars into the supporting member, or by dowels (*see 34.4.3*).

34.4.2 Where transfer of force is accomplished by reinforcement, the development length of the reinforcement shall be sufficient to transfer the compression or tension to the supporting member in accordance with 26.2.

34.4.3 Extended longitudinal reinforcement or dowels of at least 0.5 percent of the cross-sectional area of the supported column or pedestal and a minimum of four bars shall be provided. Where dowels are used, their

diameter shall not exceed the diameter of the column bars by more than 3 mm.

34.4.4 Column bars of diameters larger than 36 mm, in compression only can be dowelled at the footings with bars of smaller size of the necessary area. The dowel shall extend into the column, a distance equal to the development length of the column bar and into the footing, a distance equal to the development length of the dowel.

34.5 Nominal Reinforcement

34.5.1 Minimum reinforcement and spacing shall be as per the requirements of solid slab.

34.5.2 The nominal reinforcement for concrete sections of thickness greater than 1 m shall be 360 mm^2 per metre length in each direction on each face. This provision does not supersede the requirement of minimum tensile reinforcement based on the depth of the section.

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