

LOW COST HOUSING FOR HILLY REGIONS USING LOCALLY AVAILABLE MATERIAL

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ABSTRACT

Bamboo is used for making low cost housing in hilly regions. However, wall and roof elements made of simple bamboo mat do not last long due to their poor strength against static as well as impact loads and durability. Present paper suggests use of cement-sand mortar panels with bamboo as reinforcing material. Three types of dwelling units with varying plan area are proposed using locally available material. Cost estimate of these units are also presented for comparison.

Keywords: bamboo mat, cement-sand mortar panel, low cost housing, hilly regions

1. INTRODUCTION

1.1 Bamboo housing

Problem of housing is assuming alarming proportion with the passage of time in developing countries. The recent phenomenal rise of prize of building materials and construction costs have stood in the way of providing cheap houses for millions of people. Best way of making a low cost house is to make best use of locally available material. Bamboo is available in most of the hilly regions and had been in use for construction of dwelling units [1-6]. However, such houses get damaged due to landslides and erosion of soils due to heavy rains. Boulders rolling down during earthquakes hit wall and roof elements made of bamboo mat thus causing their failure.

1.2 Cement-sand mortar panels

Bamboo mat panels, generally used as wall and roof elements in housing in hilly regions, are not able to bear heavy stresses under static or impact loads caused due to soil and boulders falling down the slopes of hills. However, if bamboo mat (Figure 1) or bamboo mesh (Figure 2) is used as reinforcing material in panels made of cement-sand mortar, it can withstand sufficiently large values of both static as well as impact loads [7-8]. Therefore, it is recommended to use bamboo based cement-sand mortar panels as wall and roofing

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elements in dwelling units made in hilly regions.

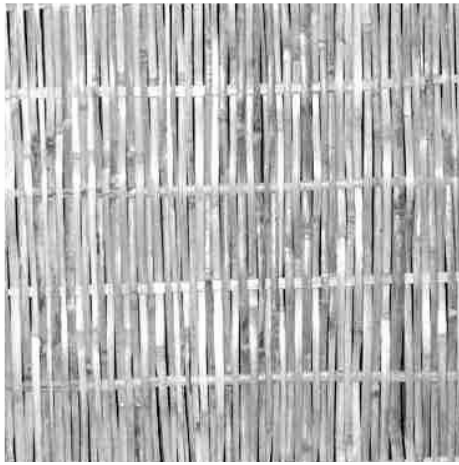


Figure 1. Bamboo mat panel

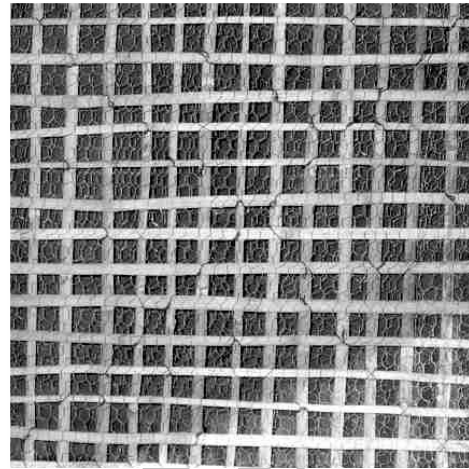


Figure 2. Bamboo mesh panel

To make bamboo mat panels, bamboo splits, made from air seasoned locally available matured bamboo, of size 10-12 mm width and 6-8 mm thickness are laid horizontally at certain distance. Then closely spaced vertical splits are knitted through horizontal splits, Figure 1. The surface of bamboo mat thus prepared is treated with hot bitumen coating on both sides and clean course sand sprinkled on it for the purpose of providing proper bond between mortar and mat. Chicken wire mesh of size 25 SWG is tied to the mat on both faces through 22 SWG, G.I. wire, Figure 3. Cement-sand plaster of 1:6 mix is applied on both faces with average thickness of 12 mm each, Figure 4. Final thickness of the panel thus obtained is around 38 mm. These panels are cured for 28 days to gain full strength.

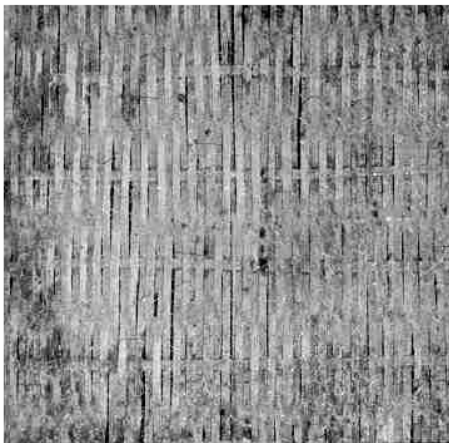


Figure 3. Bamboo mat panel after treatment with bitumen

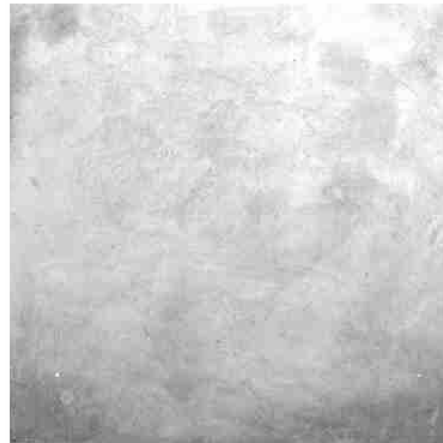


Figure 4. Bamboo mat/mesh panel finished with cement-sand plaster

1.3 Present study

Attempt has been made in the present paper to suggest certain designs of dwelling units to be constructed in hilly regions using locally available materials. Three plan forms namely (i) one room house, (ii) two rooms house and (iii) two rooms with kitchen and bath facilities, with plinth areas of 11.25 m², 22.5 m² and 33.0 m² respectively, are recommended. Detailed dimensions and material of construction are described in the following articles. In order to be able to have the idea of the total cost involvement, cost estimate of these units are also presented herein. Figures 5-6 represent a model of such a house with one room basically made with bamboo based cement-sand panels as wall and roofing elements.

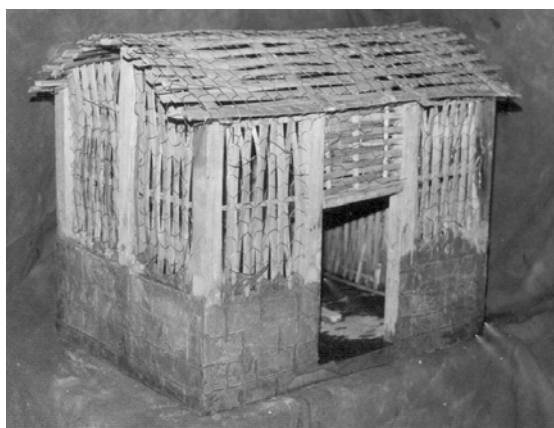


Figure 5. Model of bamboo mat house without finish



Figure 6. Finished bamboo mat house model

2. SINGLE ROOM HOUSE

Plan of the proposed single room house of size 3.00 m x 3.75 m is shown in Figure 7 and its sectional elevation in Figure 8. Material of construction to be used in various components of the building, are described below.

2.1 Foundation: The foundation is made of cement concrete (1:3:6) pedestals of cross-section 300 mm x 300 mm and height 700 mm (500 mm below ground and 200 mm above ground up to the plinth level) over which timber columns rest, Figures 7-8.

2.2 Super-structure: Super-structure is made of columns and walls. Columns are made of 100 mm x 100 mm square section timber. Walls of 2.8 m height are made of 38 mm thick cement-sand (1:6) mortar coated bamboo mat panels. To limit the size of bamboo based cement-sand panels and to hold the panels vertically in position, additional timber sections of cross-sectional dimensions 75 mm x 75 mm are used horizontally (at lintel level) as well as vertically, Figure 8.

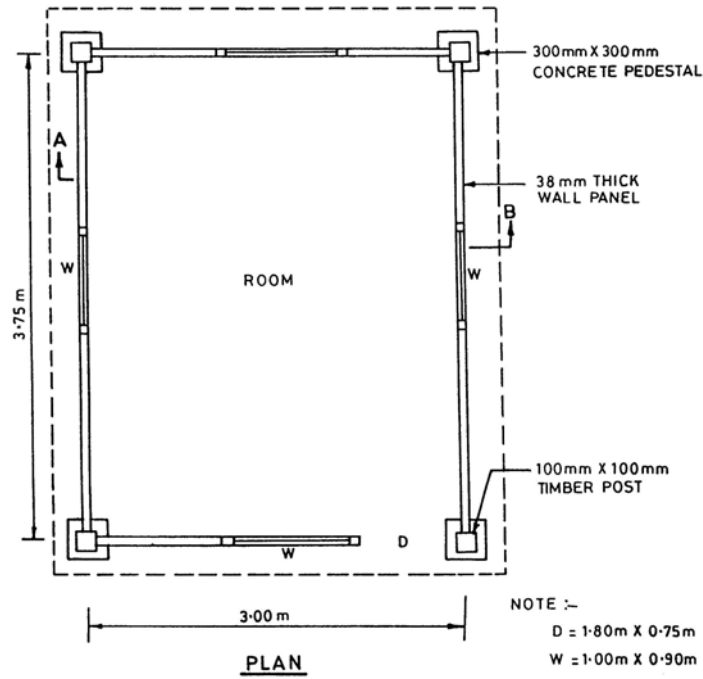


Figure 7. Plan of one room house

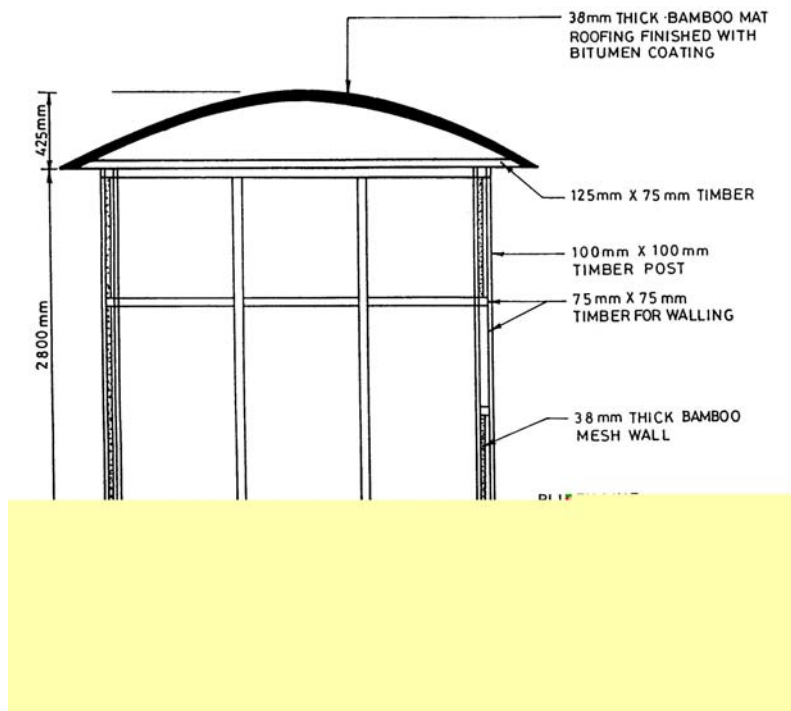


Figure 8. Sectional elevation of one room house

2.3 Flooring: Flooring consists of stone soling covered with 25 mm thick plain cement concrete (1:2:4) with smooth finish.

2.4 Roofing: Roof is made of 38 mm thick bamboo based cement-sand mortar shell elements with a rise of 425 mm and is covered with a thin layer of bitumen for making it water proof. In this case there is only one shell of size 3.00 m x 3.75 m in plan.

2.5 Doors and windows: Door and window shutters are made of second class timber planks and are fixed to vertical timber sections of 75 mm x 75 mm cross-sectional dimensions.

3. TWO ROOMS HOUSE

Proposed two rooms house, to be built using basically bamboo based cement-sand mortar panels, has total plan area of 6.00 m x 3.75 m, Figure 9. It has one bed-room of size 3.00 m x 3.75 m, one multi-purpose room of size 3.00 m x 2.75 m and one covered verandah (platform) of size 1 m x 3 m. Foundation, superstructure, flooring, doors and windows are made similar to one room house. Whereas roof is also made of similar material, i.e. 38 mm thick bamboo based cement-sand panel in shell form, it has 3 shells of size 2.00 m x 3.75 m in plan, Figure 10.

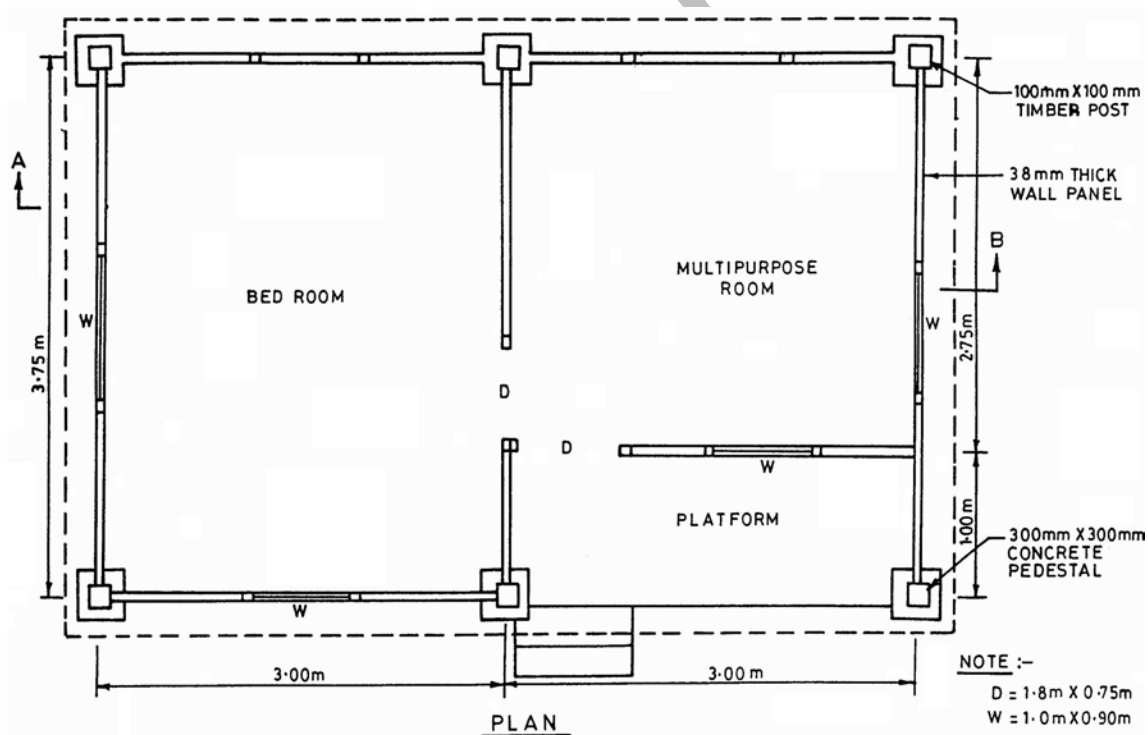


Figure 9. Plan of two rooms house

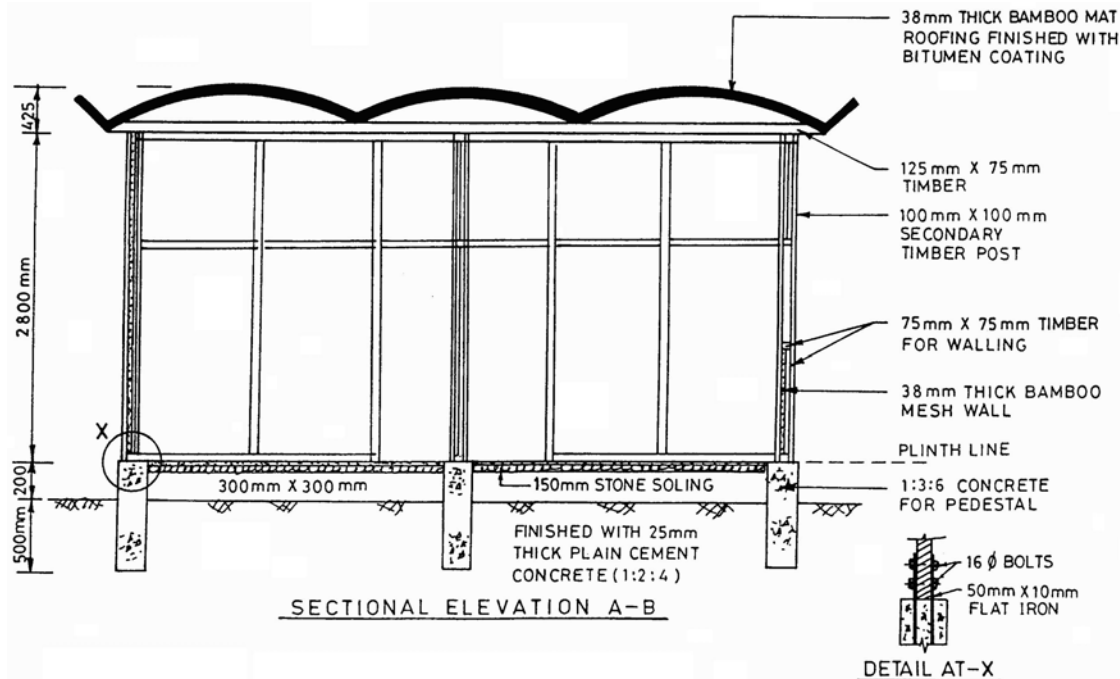


Figure 10. Sectional elevation of two rooms house

4. TWO ROOMS HOUSE WITH KITCHEN AND BATH FACILITIES

Figure 11 shows the plan of proposed two rooms house with kitchen and bath facilities. It has one bed-room, one multi-purpose room and one covered verandah (platform) of similar size as in previous case. Additionally it has one room for kitchen-cum-store (1.75 m x 2.00 m) and one for bath and toilet (1.50 m x 1.75 m). One additional room of size 1.75 m x 2.50 m is also available. Total covered area is 5.50 m x 6.00 m in this case.

Whereas foundation, flooring, roofing, doors and windows are made similar to above mentioned two room house, walls are made differently, Figure 12. Lower 0.80 m height of wall from plinth level is made of precast lean cement-concrete (1:4:8) blocks of size 300 x 200 x 150 mm resulting in a wall thickness of 150 mm. Advantage of using these blocks is in achieving thermal comfort in working zone area and protecting lower portions of the wall from the influence of rain water. Bamboo based cement-sand mortar panels of thickness 38 mm are fixed for another 1.8 m height on top of the concrete block masonry wall.

5. COST ANALYSIS

To get the cost estimate of proposed all types of dwelling units detailed above, schedule of rates of the Public Works Department of the state is made used. Table 1 gives cost comparison for three proposed units in terms of total cost of construction as well as cost per unit area.

Cost of construction of one room house comes out to be Rs. 1,740/- per sq.m. including the cost of timber and bamboo. It reduces to Rs. 1,130/- per sq.m. when only royalty charges are considered in case of timber and bamboo. In case of two rooms house i.e. with double the plinth area, the rate of construction gets reduced to almost 80% as compared to one room house. When kitchen and bath facilities are added, the rate of construction becomes almost equal to that in case of one room house. All these rates of construction are very much lower than those for dwelling units of similar plinth area but constructed with brick masonry walls and flat (R.C.C. or R.B.C.) or sloping (G.I. or A.C. sheet on steel trusses) roof.

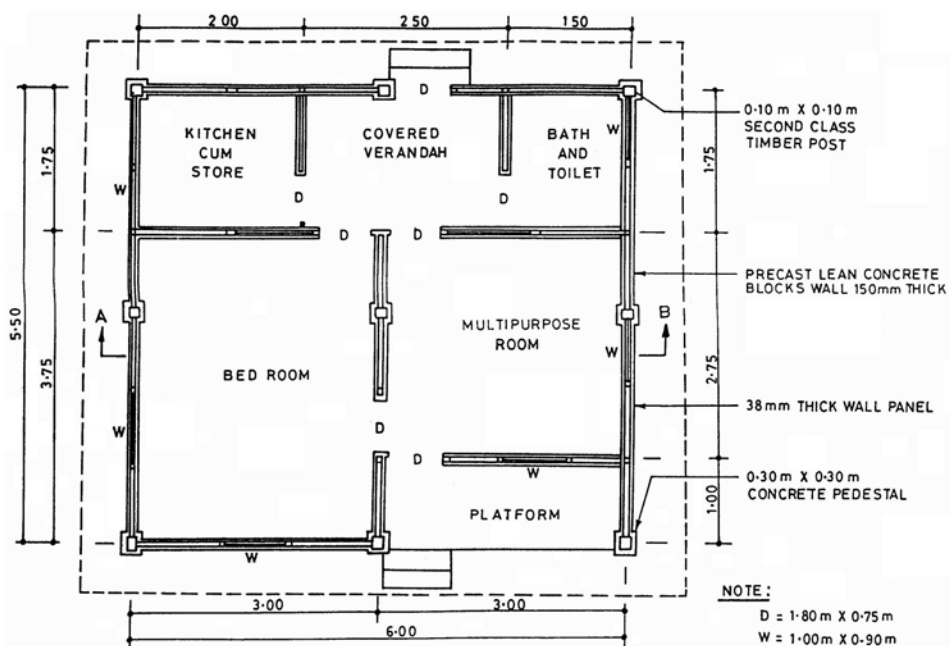


Figure 11. Plan of two rooms house with kitchen and bath facility

Table 1. Cost comparison of dwelling units

Sl. No.	Type of dwelling unit	Plinth area (m ²)	Cost of dwelling unit (Rs.)			
			Cost including timber and bamboo		Only royalty charges taken for timber and bamboo	
			Total cost	Cost per sq.m.	Total cost	Cost per sq.m.
1	One room house	11.25	19,575	1,740	12,700	1,130
2	Two rooms house	22.5	32,400	1,440	18,000	800
3	Two rooms house with kitchen and bath facilities	33.0	57,090	1,730	36,960	1,120

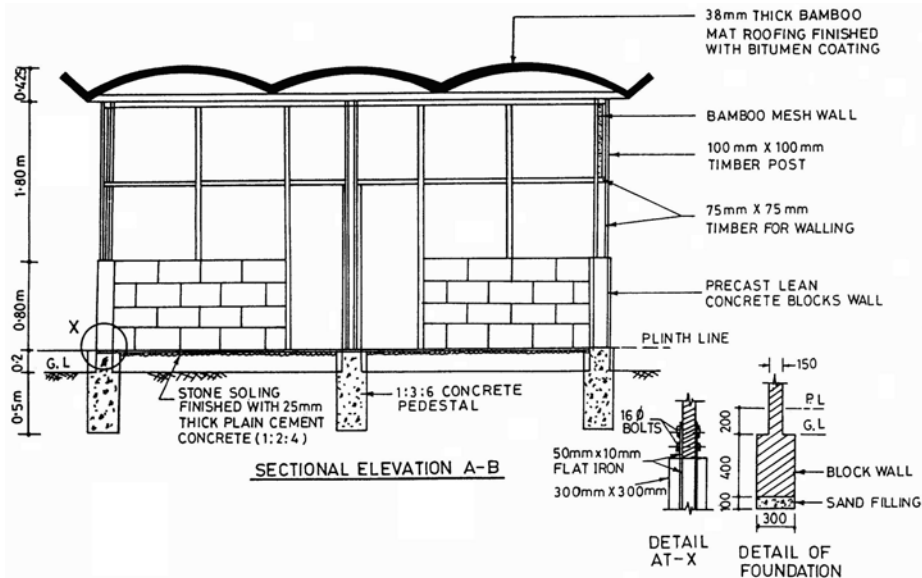


Figure 12. Sectional elevation of two rooms house with kitchen and bath facility

6. CONCLUSIONS

The main objective of the study presented herein is to develop construction techniques for making dwelling units in hilly regions using locally available materials. In the forms of dwelling units proposed, extensive use of bamboo for wall and roof elements is recommended.

Use of other locally available materials such as second-class timber, stone, sand along with cement is also explained. Following conclusions are drawn from the present study.

1. Construction of bamboo based cement-sand mortar elements is quite simple requiring no expertise and can be done on “Do-it-yourself” basis.
2. The bamboo-based roof is good substitute for G.I. or A.C. sheets. It does not require any supporting system like a truss. Additionally, it gives better appearance.
3. Treatment given to bamboo-mat with bitumen coating and sand spraying gives better bond with cement-sand plaster. The wire-mesh also increases the bonding capacity between bamboo strips and plaster.
4. Lean cement concrete blocks have strength better than clay bricks but found cheaper than bricks.
5. Construction of dwelling units in hilly region using locally available material with bamboo as prime material of construction, as proposed, is an economical proposition.

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