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Devendra Sharma
*Central Building Research Institute, Roorkee, India*

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# Foundation Strengthening and Protective Measures for Sri Sangameshwar Temple at Kudal Sangam, Karnataka

**Devendra Sharma**
Scientist Coordinator, Geotechnical Engineering Division, Central Building Research Institute, Roorkee, India

**SYNOPSIS :** Sri Sangameshwara temple situated at the confluence of two rivers developed noticeable tilt. Also the temple site be inundated by the back waters of the dam during floods. An elaborate plan of dismentling the temple and reconstructing it by the same stone pieces and statuary could be carried through partially only and the sanctum santorum portion housing the 'Lingam' had to be retained. Now the entire temple is to be reconstructed as and where it was. The temple was founded on a boulder plateform with hetrogeneous river deposits below it. Honouring the constrinats of uninterrupted daily worship rituals in the temple and the underside of the pedastal supporting 'Lingam' not to be disturbed, strengthening by providing a double row of piles around the existing structure and a protective wall around the site were recommended. The choice and design aspects of these measures are discussed.

## INTRODUCTION

Sri Sangameshwara temple is situated at the confluence of the rivers Krishna and Malaprabha in district Bijapur of the Karnataka State of India. The site is known to be an important seat of the shaivite sect of the Hindus and associated with saint Basvanna whose works are ascribed to 12th century A.D. The temple is closer to the river Krishna on its north (Fig.1) and this existing portion (Fig.2 and Fig.3) is the sanctum sanctorum known as 'Garbhgudi' housing the 'Lingam' on the pedestal. The remaining major front portion (Fig.1 and Fig.4) had been dismentled.

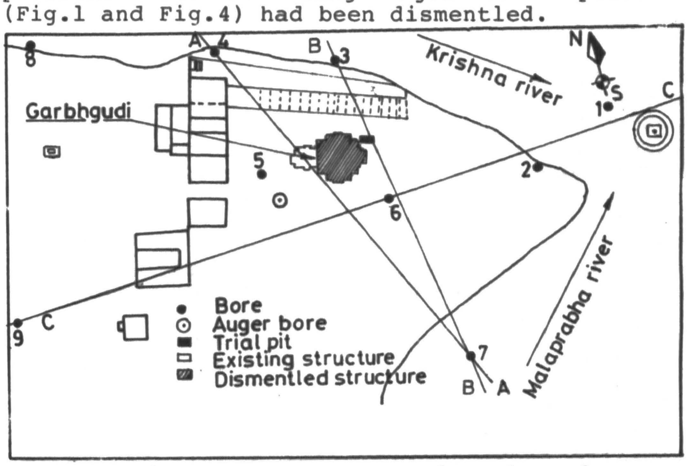


FIG.1 Sri Sangameshwara temple - key plan

The site was liable to submergence by the backwaters of the Narayanpur reservoir downstream on the river Krishna. A detailed plan of reconstructing the temple on an elevated nearby site was drawn. A careful and thorough documentation piece by piece of the stones in masonry before dimenstling and using the same afterwords was done. The dismentling started in 1984. But in view of the religious sentiments it was decided (Mudnal, 1988) to retain the existing sanctum sanctorum and to rebuild the entire temple as and where it was and to provide necessary foundation strengthening and flood protection measures also. In 1989 and 1990 the problem of foundations was investigated by Central Building Research Institute, Roorkee (Sharma, 1990).

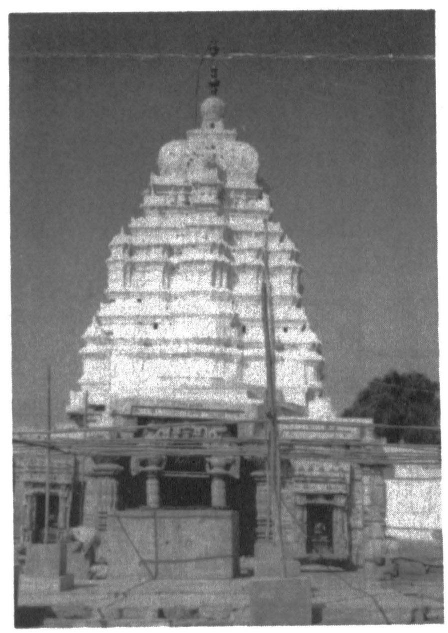

FIG.2 Front view of the temple

## SITE AND SUBSTRATA

The Naryanpur dam across the river Krishna is downstream of the temple site and the Almatti dam under construction is upstream. Across the river Malaprabha also there is dam upstream. The catchment of Narayanpur dam whose backwaters, specially during the floods,



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FIG.3 Back view from south-west

endanger the temple site, has an area of 6400 sq.km. The area around the confluence is generally 'black cotton soil', expansive clays, covered country. The basement rock as revealed by mine boreholes at the site (Fig.1) was granite and its variants. The ground levels varied from 482m to 492m and hard rock encountered from 470m to 480m and an overburden of 1.5m to 21.0m thick (Report, 1987). the present floor level at the temple is around 493m. The likely depth of the basement rock indicated by sections AA, BB and CC through the boreholes (Fig.1) is at an elevation from 475m to 470m. These boreholes showed no general sequence of deposit layers which varied from soil to boulders and mixed hetrogneous

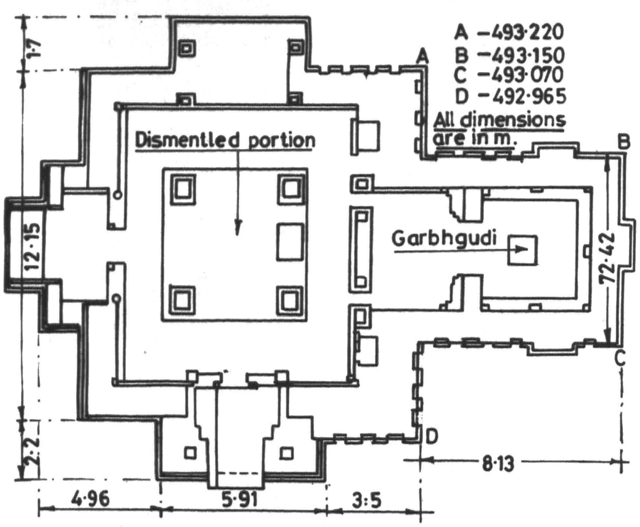


FIG.4 Temple plan

materials. The temple seems to be located over a depression in the basement rock and the bdorehole B6 (Fig.1) showed the lowest badrock level at 470.31. Both the site and the badrock below had an overall general slope towards the north and northeast. The closer proximity of the river on the north side and general ground to north are important to note. The same slope would have existed prior to the temple construction. According to the classical Hindu temple architecture slope of the site is an important consideration for the choice nof the site (Sharma, 1988) and a site sloping towards, north, north east or east is considered auspicious (Mansar, 1951; Namboodriped, 1987, Kulkarni, 1985). Specially northword slope is more important for Shaivite temples. Several Indian classics on architecture support this practice.

The borehole made by augering and a pit dug at the site (Fig.1) showed strata as given in Fig.5. There is a trend of increasing finer fractions, higher liquid limits and swelling with depth. The lower strata soils in borehole and the soil in the interspaces of the boulders below the temple are of compressibility increasing with depth.

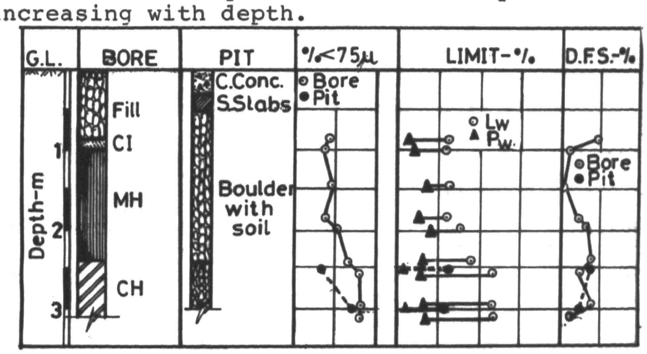


FIG.5 Bore log and pit data

**THE TEMPLE**

The temple is several centuries old and no documented details except an original temple plan carved on a rock outcrop (Fig.6) at a place few kilometers away from the temple could be available. This plan is at the temple plinth level and if it is the complete layout, the original temple had only a smaller structure leading to the entrance of the sanctum sanctorum. Now diementled front portion within a square of about 16m sides (Fig.4) must be a later addition. A part ofthe originally constructed front is still retained (Fig.2). The sanctum sanctorum structure at its base is within 7.5m x 7.5m (Fig.4) and with a total height of 16m upto temple top above the present floor level. The granite stone masonry with exquisite carvings Fig.7 has a wall thickness of about 1m and is 5.6m high. The remaining tapering top structure is plastered brick work with moulding (Fig.2 and Fig.3). The estimated weight of the superstructure is 1130t. The masonry on outside showed signs of weathering, obliteration of stone carvings, opening of joints and dislocation of stones (Fig.7). The brick top was also reported to have cracks in the past and repaired.

The differential settlement at the base and tilt towards north of the temple are noticeable (Fig.2) on viewing from east and west. The



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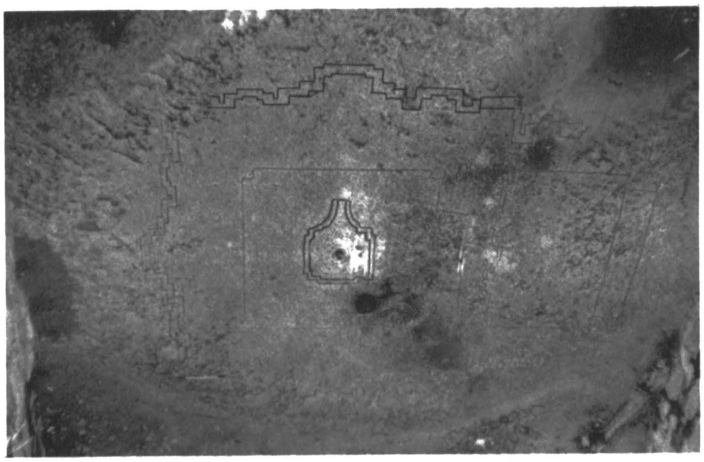

FIG.6 Original plan carved on rock

levels on the four corners of the existing structure taken in 1987 (Report, 1987) are shown in fig.4 and these showed no change during the period of three years upto 1990. The tilt of the back side between B and C towards north is 1 in 84 and between A and D is 1 in 51. The tilts show that there is tilt towards east also. The difference of levels between points B and C is 0.08m. As the temple is with massive walls with tapering top with a series of corbels, the entire structure may be considered to tilt by the same amount as its base. The overall tilt and general ground slope are in the same direction i.e. the north/north east.

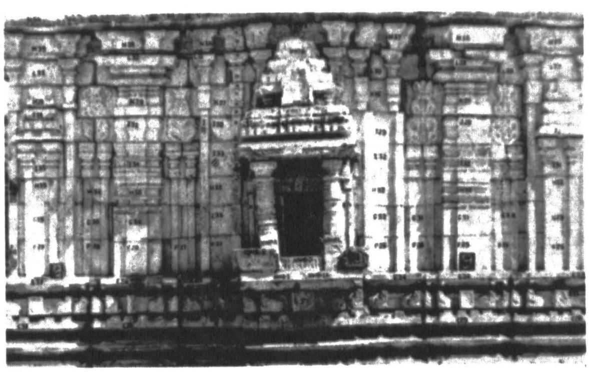

FIG.7 A view of back wall

**FOUNDATION PERFORMANCE AND STRENGTHENING MEASURES**

The foundation, as indicated by digging the pit showed stone slabs upto 0.23m depth laid over large size boulders wedged by smaller ones and interspaces filled by soil and few brick bats. This was upto 2.5m and below this still larger boulders (1m size) were encountered and further digging beyond 3m below the floor level could not be possible. This indicates that the temple structure was raised on a boulder plateform. This is according to the traditional classical architectural practice of constructing temples on made up strong platforms. However, it is not certain that the boulders are right upto the badrock. Below the boulders there could be other hetrogeneous deposits of gravel and soil also. The foundation platform is more than 3m thick. The 'Lingam' on its pedastal in 'Garbhgudi' is resting independent of the structure and this too is tilted and is at a level below the surrounding receptacle to drain the water in 'Abhisekam' ritual. Perhaps the 'Garbhugdi' has a central depression in its floor to accommodate the pedastal of 'Lingam'.

The total weight of the structure is 1130t over a square pad of (say) $7.42m^2$ giving pressure intensity of 20.52 $t/m^2$. It can be concluded that any consolidation of soil should have been over long ago during the temple existance for centuries. Therefore, the problem of tilt might have arisen due to sudden readjustment of strata. It is reported that during the earlier years of the second decade of the present century, the temple site got submerged by flood waters. Later on a portion of the protection wall on the bank of the Krishna collapsed and caused erosion of the bank on the north and the tilting occured. This could lead to the tilts towards north. The temple structure is symmetrical along the east-west axis and cannot cause differential loading to cause tilt towards north. Nearness of the river and erosion are major factors leading to tilt. Also water used in rituals cannot drain out and seeps into floor and under the northern side wall. The wall on the north bank had been restored. Now the tilts are stable.

The remedial measures for the correction of differential settlement by lifting up and/or pushing down were not favoured due to poor condition of masonry and unforseen readjustment of stress in it during such corrections. The present tilts were acceptable to temple authorities provided they remain stable. The other constraints were of restricted space and nature of strata. Excavations for conventional underpinning were not feasible due to large boulders and water table. Presence of clay interspaces will not permit effective grouting. The foundation treatment upto deep badrock (Report 1987) was not really called for as the foundation pressures are not much. Besides, for any measures the overriding conditions were uninterrupted worship rituals in the temple and the underside of the 'Lingam' pedastal in 'Garbhgudi' and the foundation below was not to be disturbed. The later is an important condition for rennovation of a temple (Munshi, 1965) and if such a disturbance occurs it becomes a case of a completely new construction of a temple needing the elaborate ritual of 'Pranpratishtha' for starting worship in the temple.

The suggested remedial measure consisted of provision of double row of bored piles around the existing structure, scheme shown in Fig.8 and Fig.9. If the base is made to act like a plug between the enclosure, the lateral deformations are checked (Kuzimanovic, 1970) and studies (Narhari, 1970) have shown that there is a significant advantage by skirting depth equal to half of the footing width in reducing settlements. In the recommendations


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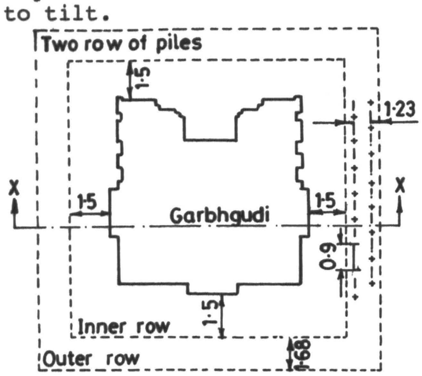
the suggested depth is 0.75 times the width of the enclosed square area which is still more advantageous. The base is of stone slabs and boulders and some of them protruding out may be accommodated in the pile cap (Fig.9). The treatment is on the outside and will not interfere with the daily routine of worship. In this case the action will be more like a block footing (Peck, 1974) of piles on periphery and enclosed strata within acting as one unit. The dimensions of this block will be 10.73m x 10.73m x 9.3m deep. Considering both bearing at base and friction on sides of the block the ultimate bearing capacity for average cohesion of 4 $t/m^2$ works to be 5,275 t against the estimated load of temple of 1130t giving ample margin of safety and lesser intensity of loading safeguards against settlements also. The massive block of foundation will act integral part of superstructure above it and lower down the centre of gravity of the super-structure with substructure and reduce overturning movements and differential loading leading to tilt.




PLAN
+ Position of pile centre
(All dimensions are in m)

FIG.8 Piles around Garbhgudi

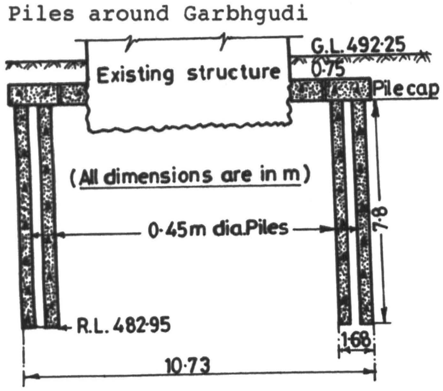



FIG.9 Pile enclosure around 'Garbhgudi'-section

The other protective measures suggested already were a protective wall around the entire temple complex with the top at elevtion 496.00m and complex platform at 496.5m with an under-drainage system. This will provide adequate margins for the normal operating levels of 492.25m of the Narayanpur reservoir downstream.

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