DYNAMIC ANALYSIS OF A HYDRO-ELECTRIC POWER HOUSE STRUCTURE

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SUMMARY

Power house structures could have complex framing due to functional requirements. For purposes of design the usual practise is to analyse the structure as a system of independant frames. This approximation is justified for preliminary design but final design should be based on space frame analysis of an appropriate mathematical model.

This paper describes the behaviour of the auxiliary building of a power house in India and discusses problems associated with the idealisation of the structure into an equivalent space frame. Results of space frame analysis have been compared with conventional analysis and the limitations on design has been broughtout.

INTRODUCTION

Hydro-electric power houses and their auxiliary structures consist of a complex assemblage of heavy outer walls, light or heavy partition walls, and the usual beam, column and slab arrangements. Further, functional requirements dictate the provision of large column free areas for the installation or movement of heavy machinery and allied components. Inspite of the presence of such diverse component units the usual design office practise consists of considering the assemblage as a set of independant plane frames.

IMPROVED MATHEMATICAL MODEL

The design office procedure indicated above may be justified for determining the preliminary dimensions of members but is inadequate for final design since it neglects a) presence of cross beams, b) stiffness contribution of heavy outer walls, and c) slab interaction with the framework. A space frame analysis would provide a better estimate of the force distribution but it neglects the presence of slabs in the skeletal system. The resulting mathematical models are relatively more flexible than the parent system especially when plane frames are considered independantly. The performance of the mathematical models could be improved by modifying beam properties so that the effect of slabs is incorporated based on (1), i) the rigidity of slabs in resisting in plane deformations and, ii) the stiffness contribution of slab towards restraining all beam deformations.

The above indicates that beams associated with slabs (or columns monolithic with walls) will have an increased effective section for evaluation of areas and moments of inertia. In the absence of an established rationale this was achieved by considering the beam integral with adjoining slabs. This criteria was adopted for both 2D and 3D analysis.

NUMERICAL RESULTS

One of the frames analysed is 21.375 m in length and 9.50 m in width. The geometric configuration is such that two bays are two storeyed while

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the third is raised and has a single storey. Further, the upper storey has a sloping roof which is supported on columns having a height of 5.00 m at one end and 4.50 m at the other. The frame alongwith the 2D component frames is as shown in Fig. 1.

The results of free vibration analysis are as indicated in Table I, while results of static analysis and spectral analysis are as shown in Table II which consists of beam moments for two component frames as indicated in Fig.1. The results of dynamic analysis are for similar deformation modes and consist of forces in one mode only.

CONCLUSIONS

The present study indicates that

i) Under the action of static loads, though no set pattern was observed, in general 2D analysis underestimates member end forces.

ii) The fundamental period of vibration in 2D analysis is underestimated by end frames but overestimated by intermediate frames when modes of similar deformation are compared.

iii) In 2D analysis the first mode is responsible for a large percentage of the total response whereas in 3D analysis even the third mode shows a significant contribution towards the total response.

iv) The member forces evaluated by SRSS combination of individual modal contributions indicates that 2D analysis yields much lower forces as compared to 3D analysis.

REFERENCES

1. Chandrasekaran, A.R., Pandey, Ashok D., Khetarpal, Rakesh., Oct. 1978, Dynamic Analysis of the Auxiliary Building of the Power Plant of the Koyna Hydroelectric Project, Earthquake Engineering, University of Roorkee, Roorkee.

TABLE-I SUMMARY OF FREE VIBRATION ANALYSIS

Mode	TIME PERIOD (SEC) AND MODE PARTICIPATION FACTOR				
	SPACE FRAME	PLANE FRAME			
		AYX1	AYX4	AYZ1	AYZ4
1	0.2088	0.1857	0.2044	0.1873	0.1859
	(1.1567,0.0011,0.1018)	(1.0006)	(1.4085)	(1.0105)	(1.0084)
2	0.1940	0.0181	0.0989	0.0290	0.0244
	(-0.0872,0.0003,1.0552)	(-0.0132)	(0.4691)	(0.0006)	(0.0406)
3	0.1833	*	*	*	*
	(0.2566,0.0008,-0.2248)				
4	0.0561	*	*	*	*
	(1.1933,0.0067,0.0113)				

NOTE: Values in parenthesis indicate mode participation factors corresponding to motion in X, Y and Z directions for space frame. X direction for AYX1 and AYX4 and Z direction for AYZ1 and AYZ4.

TABLE-II COMPARISON OF MOMENTS FROM 2D AND 3D ANALYSIS

BEAM	STATIC ANALYSIS				DYNAMIC ANALYSIS			
	2D		3D		2D		3D	
	M_i	M_j	M_i	M_j	M_i	M_j	M_i	M_j
BX1	-0.88	-0.11	1.02	0.23	-25.88	-18.66	-35.96	-25.85
BX2	0.28	-0.03	-0.36	0.08	-14.40	-13.98	-20.29	-19.70
BX3	0.10	0.66	-0.21	-0.78	-17.37	-23.03	-23.97	-32.01
BZ1	-4.54	-1.14	-5.18	-0.91	-24.09	-17.77	24.67	17.42
BZ2	1.93	1.20	1.71	0.49	-12.67	-11.77	12.11	11.53
BZ3	0.92	2.04	1.69	2.57	-18.58	-25.22	17.54	25.00
BZ4	1.36	1.60	-1.29	-0.48	- 4.99	- 9.46	4.54	9.00
BZ5	2.45	4.65	4.05	5.20	-19.21	-24.11	17.32	22.51

NOTE:

M_i and M_j are moments at ends of beam in t-m units.

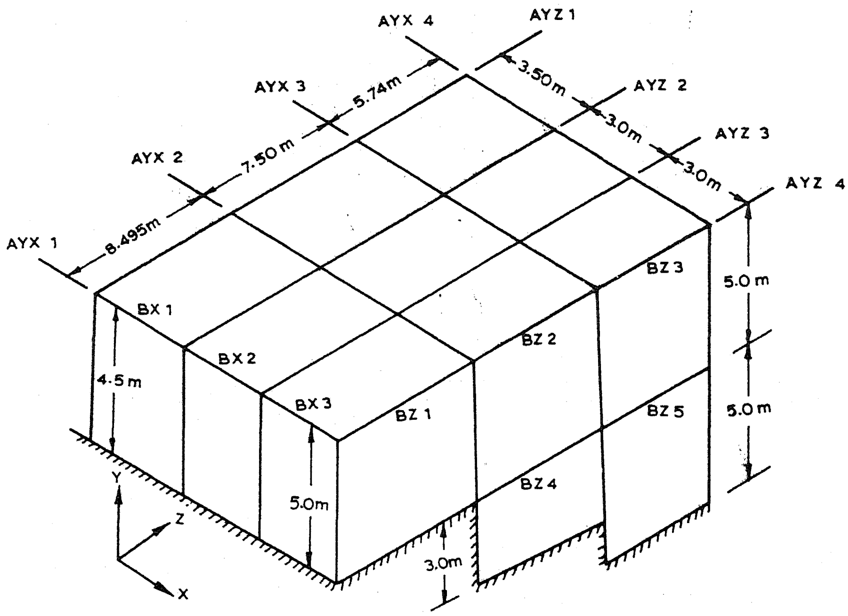

FIG. 1_PERSPECTIVE OF FRAME SHOWING COMPONENT PLANE FRAMES