TABLE 1

Acceleration of the Table and Damage to Structures

Shock	Direction From	Dead Load Wagon Position	Maximum Horizontal Acceleration: initial impact, s. side	initial impact, n. side	rebound, s. side	rebound, n. side
1	E	14.5		negligible		
2	E	15.5	0.22 g	0.20	0.14	0.10
3	E	15.5	0.40	0.34	0.30	0.29
4	W	15.5	0.51	--	0.47	0.36
5	W	15.5	0.57	0.47	0.46	0.37
	Transverse walls of PM cracked					
6	E	17	1.05	0.78	0.96	--
	Base crack all around PC, shear wall cracks in PM, RM					
7	E	17	0.83	0.84	0.71	0.84
	Transverse walls of PC bending, foundation cracks in RM					
8	W	17	Power failure			
	PM demolished, small cracks in RC					
9	W	17	1.24	1.18	1.16	1.01
	All walls of PC have wide cracks					
10	W	17	--	0.22 vert	--	--
	PC demolished, large foundation cracks in RM					
11	W	17	--	0.19 vert	--	--
12	W	17	--	0.32 vert	0.97	--
13	W	17	1.26	0.36 vert	1.06	0.55 vert
14	E	18	1.30	1.27	1.30	1.46
	RM demolished					
15	E	19	1.85	0.49 vert	1.40	0.31 vert
16	E	19	1.84	0.30 vert	1.52	0.30 vert
17	E	19	1.78	0.21 vert	1.45	0.18 vert
18	E	18	1.60	1.56	1.36	1.47
19	E	19	1.95	1.83	1.68	1.63
	RC demolished.					

Mortars:PM:plain mud, PC:plain cement, RM:reinf. mud, RC:reinf. cement

Decisions To Be Made About The Testing

1. It is not presently possible with any testing facility to duplicate the triaxial base input accelerations to a structure caused by an earthquake. Furthermore, all earthquakes are different, and the motions of future ones are unknown. The question of what should be the character of the input accelerations in a test facility will always be with us. The facility at Roorkee can provide only simple pulses, so the choices are limited, but the question must still be answered. How should the amplitude of the acceleration pulses be varied in the sequence of application? Should amplitudes be uniform, be steadily increased, or be held constant for several pulses and then be increased stepwise? In Figure 9 are shown examples of these possibilities.

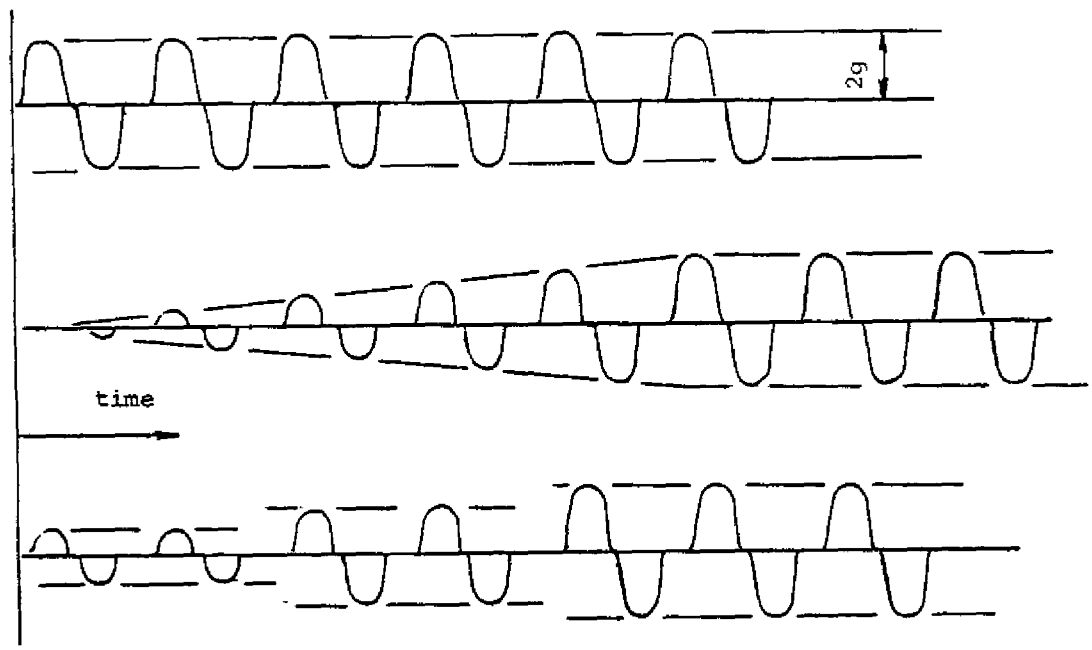

FIG. 9
Three possibilities for pulsing the structures.

2. How should damage be evaluated as a test progresses? Is there a way of realistically quantifying damage by measuring cumulative length of cracks, volume of cracks, permanent roof deflection, the ratio of roof acceleration/base acceleration, or some other condition or behavior?

3. What should be the size of the test structures? In the first test, in 1977, four structures roughly 2.0 m square were mounted on the table simultaneously as shown in Figure 10. Such an arrangement would permit 24 structures to be tested in one year, whereas only six could be tested if one structure filled the table. Do half scale models when tested at doubled acceleration behave the same as full scale models? Although the inertial stresses in the half scale models would equal those in the full scale models, the gravitational stresses in half scale models would be only half as large. Should the test

structures be oriented with the axes of the table, or at 45°, so that walls experience both inplane and out-of-plane forces?

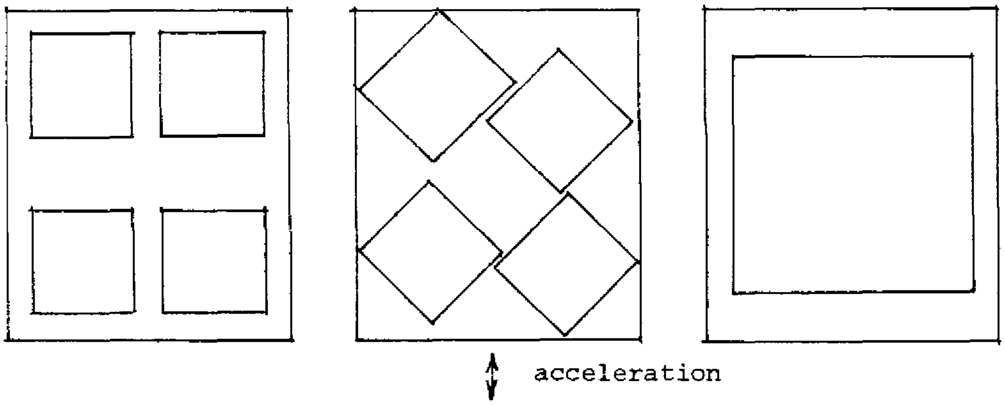

FIG. 10
Possible arrangements of structures on the table.

4. How much instrumentation should be employed? Surely, base accelerations will be measured. Is it worthwhile to measure roof accelerations, strains, or story deformations in order to attempt to describe structural behavior, or is it sufficient to simply assess damage after each pulse? Large amounts of instrumentation can be costly and time consuming, sometimes distracting the researcher from making more significant observations.

5. If one type of structure is tested several times, there will undoubtedly be a certain amount of scatter in the results, (2). How many repetitions of a particular test should be made in view of the fact that probably only six tests can be conducted in one year? If four structures are on the table each time, should one of them always be a "standard" structure, built the same each time?

6. What should be the layout of the openings in the walls of the test structures? In the first set of tests a door opening was put in a shear wall aligned parallel to the direction of the shocks, and a window was put in the center of each of the other walls, each opening occupying approximately 20% of the wall width. Should amount and position of wall openings be made variables?

7. What structural features should be tested? Since testing opportunities are limited, only the most important features can be considered. Below are listed features about which decisions will need to be made:

   (a) Solid reinforced concrete roof slab, or wood beams (parallel to pulses or perpendicular) overlaid with smaller cross pieces and a layer of clay, or a sloping roof of wood poles or trusses covered with clay tile or corrugated sheet steel?

   (b) Corners reinforced by buttresses (counterforts) built integral with the walls, and walls reinforced with pilasters (local thickening) at mid-length, or corners reinforced with wood columns fixed in the foundation, embedded in the walls, and attached to the roof or the bond beam, or corners made of brick laid in cement mortar with steel reinforcing bars attached to the bond beam or to the roof, or unreinforced corners?

(c) Walls reinforced with vertical canes around which is poured a cement of some kind to bond the cane with the wall, perhaps a mixture of sand and clay slurry, the cane being wire tied to or embedded in the bond beam?

(d) Walls containing horizontal reinforcement in the form of barbed wire stretched between corner posts, if any, or small canes or other wood placed between courses?

(e) Walls reinforced with a skin, inside and out, consisting of wire mesh or jute cloth stretched over the wall surface and then coated with cement mortar or liquid sulphur, the skins being tied together by wires through the thickness of the wall, (3)?

(f) Walls reinforced with woven matting made of split cane, set vertically between the wythes?

(g) Bond beams placed at the top of the openings, or bond beams at the top of the walls, or bond beams at both places?

(h) Bond beams made of wood, or of reinforced concrete, or of reinforced masonry?

(i) Wood knee braces between walls and roof beams?

(j) A diagonally braced wood frame which supports the roof, infilled with earth between the bracing, or earth walls which support the roof?

(k) Walls made of fired brick laid in mud mortar, or walls of air dried mud brick? The use of fired bricks in mud mortar, common in India, would speed the work and reduce the cost because the fired bricks could be cleaned of mortar and be reused. A large supply of half scale fired bricks is on hand at Roorkee.

Concluding Remarks

It is seen that the many structural variations and reinforcements mentioned, and those not mentioned, will require a great number of decisions to be made. Should the testing work proceed slowly and methodically, examining the variables thoroughly, one by one, with the hope that additional years of funding will be forthcoming for this type of work, either in Roorkee or elsewhere, (funding for this proposed work is not yet definite), or should the work progress by leaps, testing a wide variety of the variables less thoroughly? Perhaps the answer to this question will be apparent after a few test results have been obtained. The author would appreciate the recommendations of the readers.

References

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