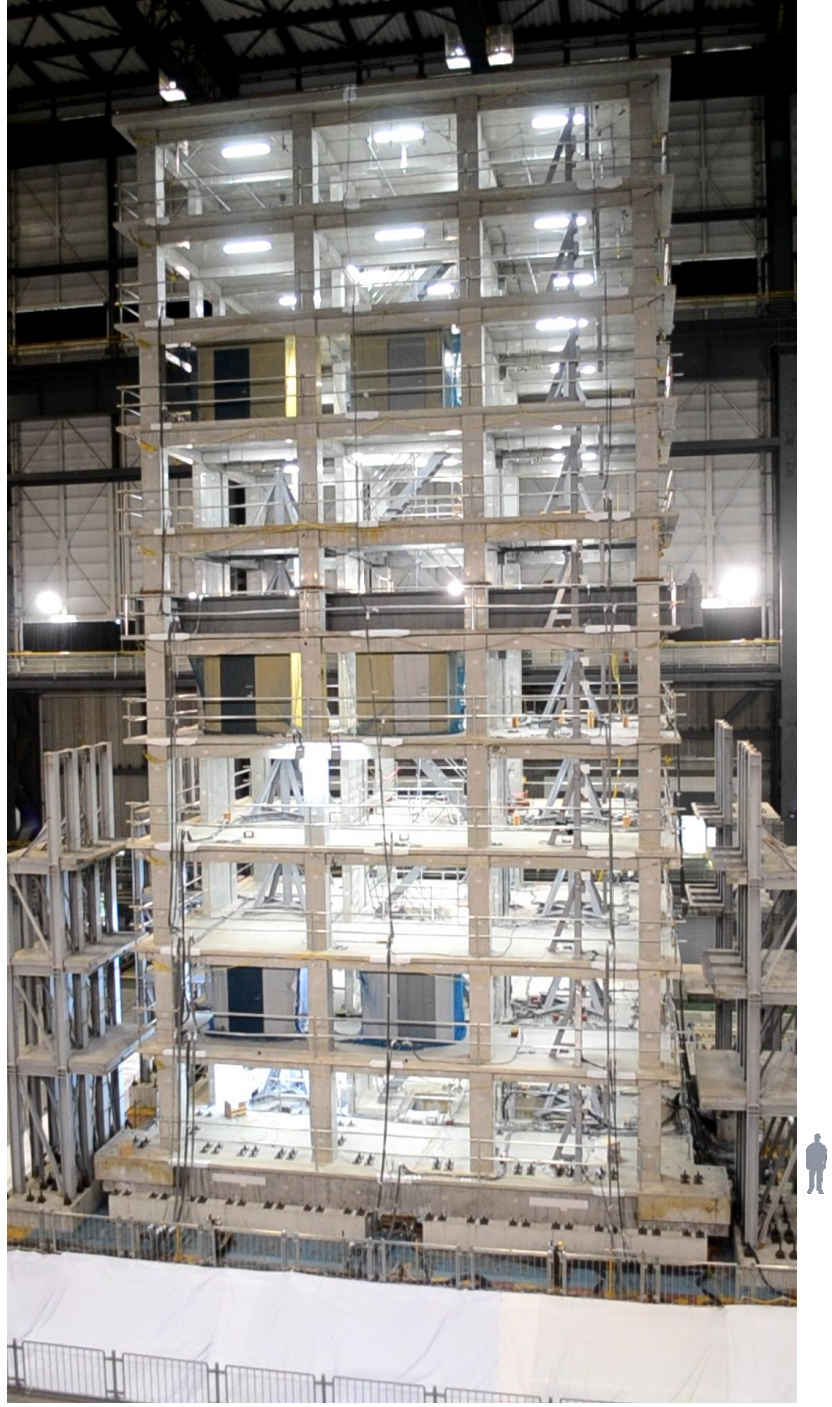
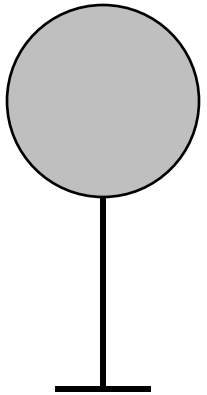
Mete's Drift-Driven Design

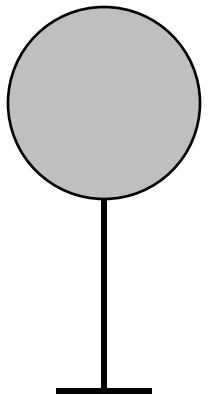


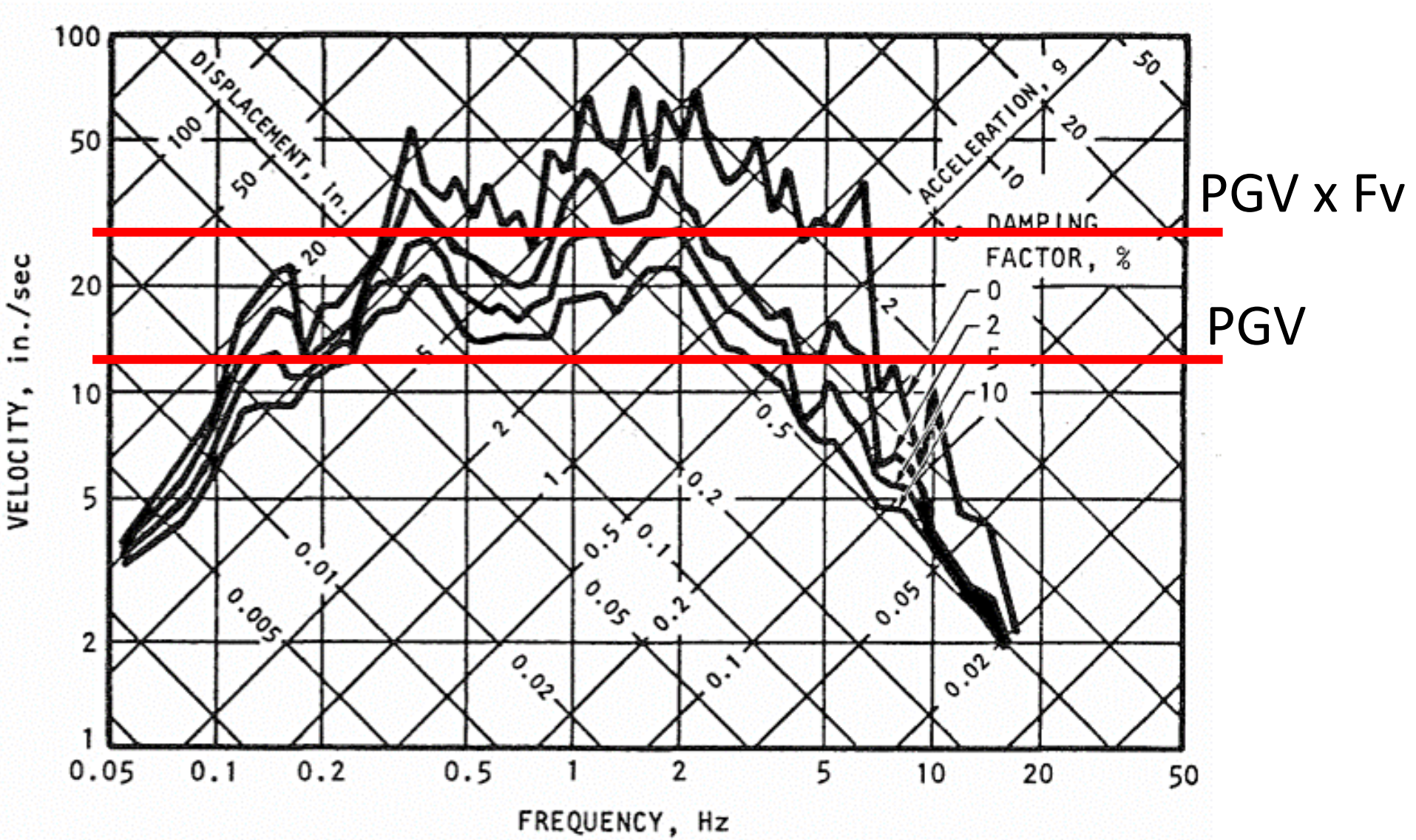
1. How far does it drift?
2. If ground motion intensity doubles does drift also double?
3. Would a second motion of similar intensity produce the same drift?
4. Would a second building with more reinforcement drift less?

NEWMARK

1973

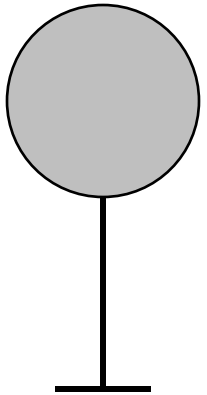





VELOCITY, in./sec
FREQUENCY, Hz
DISPLACEMENT, in.
ACCELERATION, g
DAMPING FACTOR, %
0
2
5
10
100
50
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.05
0.1
0.2
0.5
1
2
5
10
20
50

PGV x Fv

PGV



SDOF

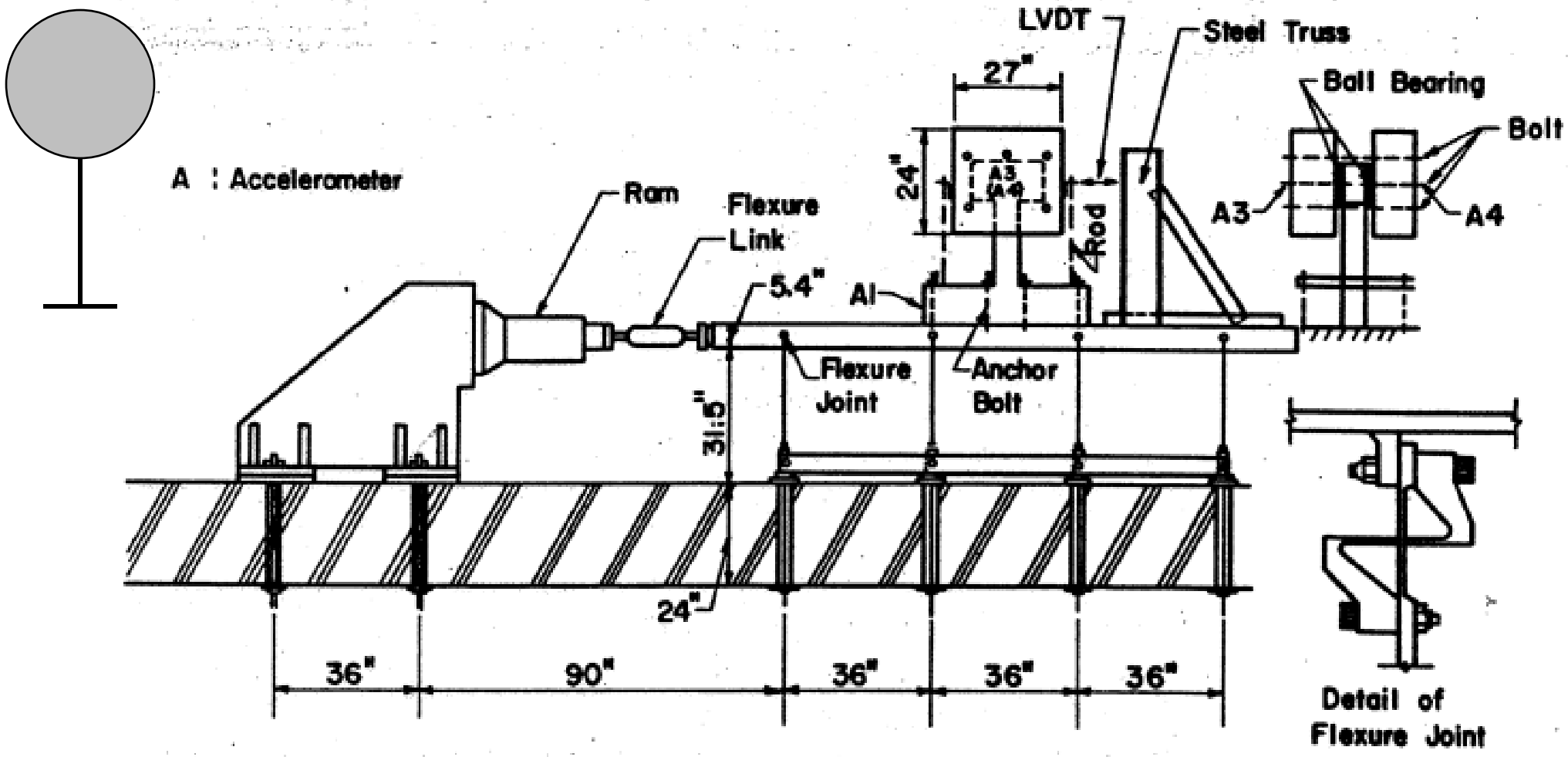
The SDOF has two supreme advantages:

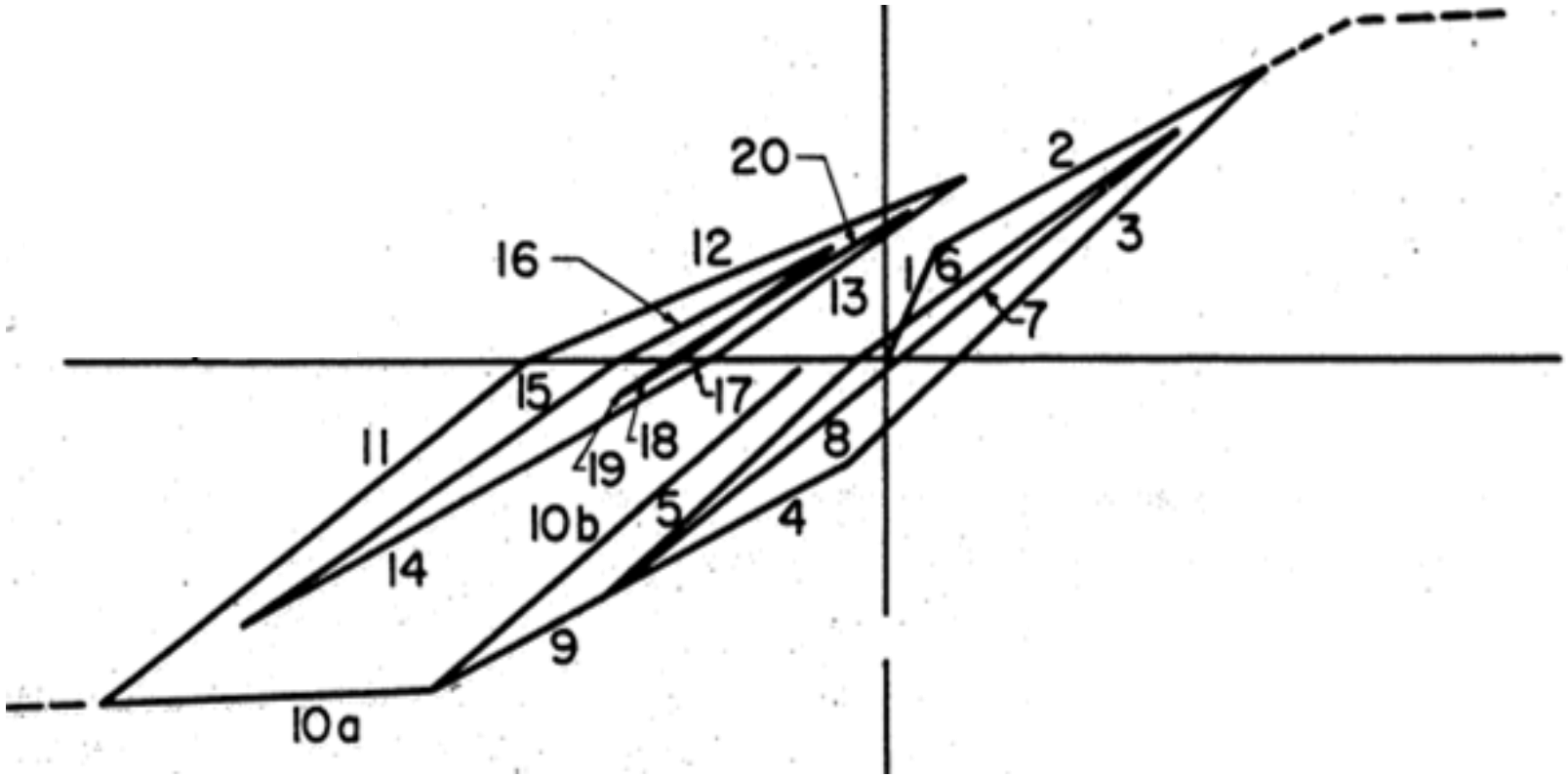
-It is easy to implement and

-It is difficult to believe it is an accurate representation of the building.

TAKEDA

1970


A : Accelerometer
Ram
Flexure Link
5.4"
A1
LVDT
Steel Truss
27"
24"
A3
A4
Rod
Ball Bearing
Bolt
A3
A4
Flexure Joint
Anchor Bolt
31.6"
24"
36"
90"
36"
36"
36"
Detail of Flexure Joint


20
2
16
12
3
16
13
7
15
17
11
18
19
8
10b
5
4
14
9
10a

With increases in intensity:

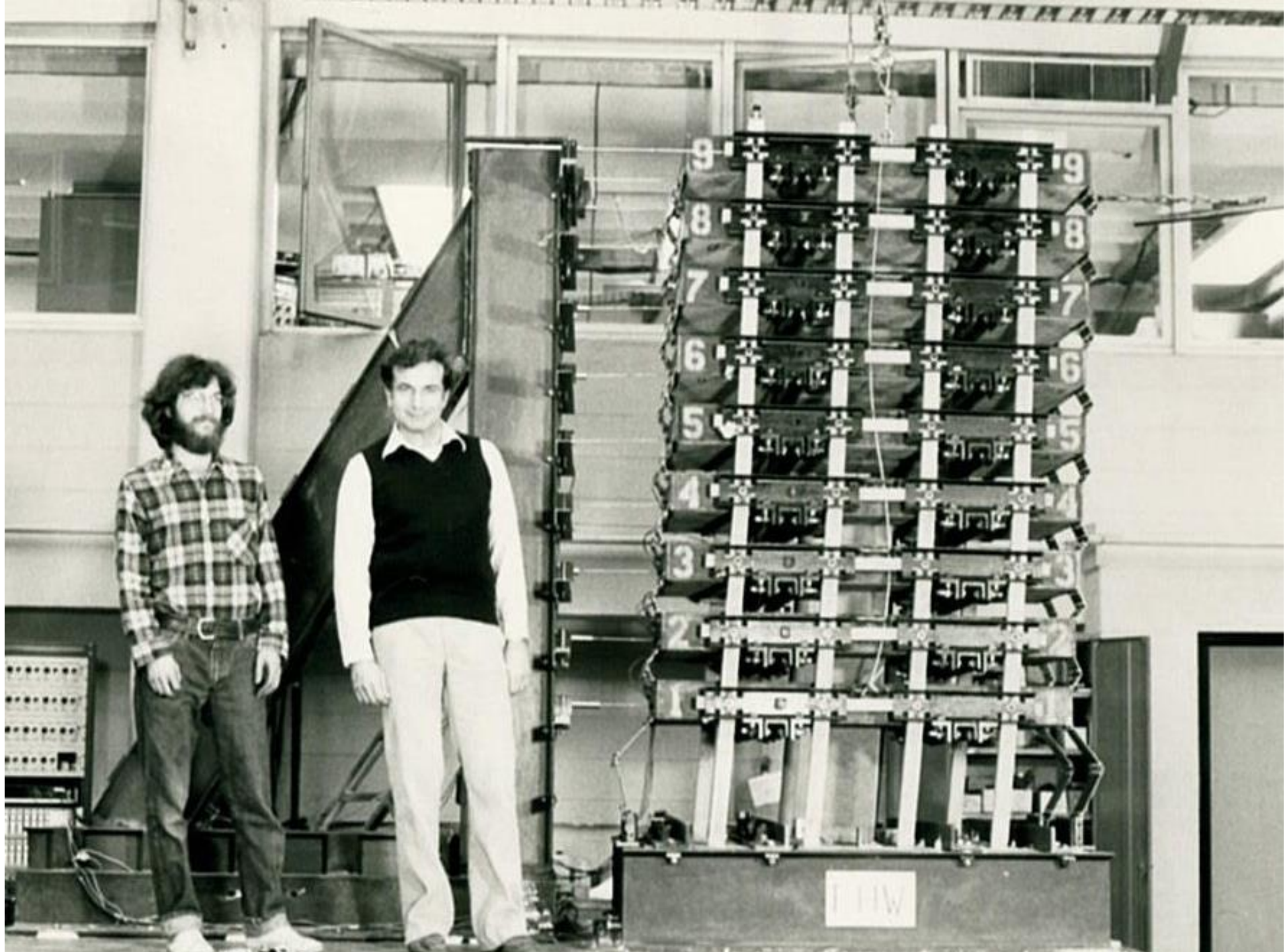
-“the measured… force tended to remain constant”

-“drift increased more or less linearly”

“Takeda and his co-workers”

- [were] “preoccupied with… reduced force”

- “did not emphasize… a direct relationship between… intensity and… drift… independent of strength.”


9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
1
FNAL

CECEN

1979

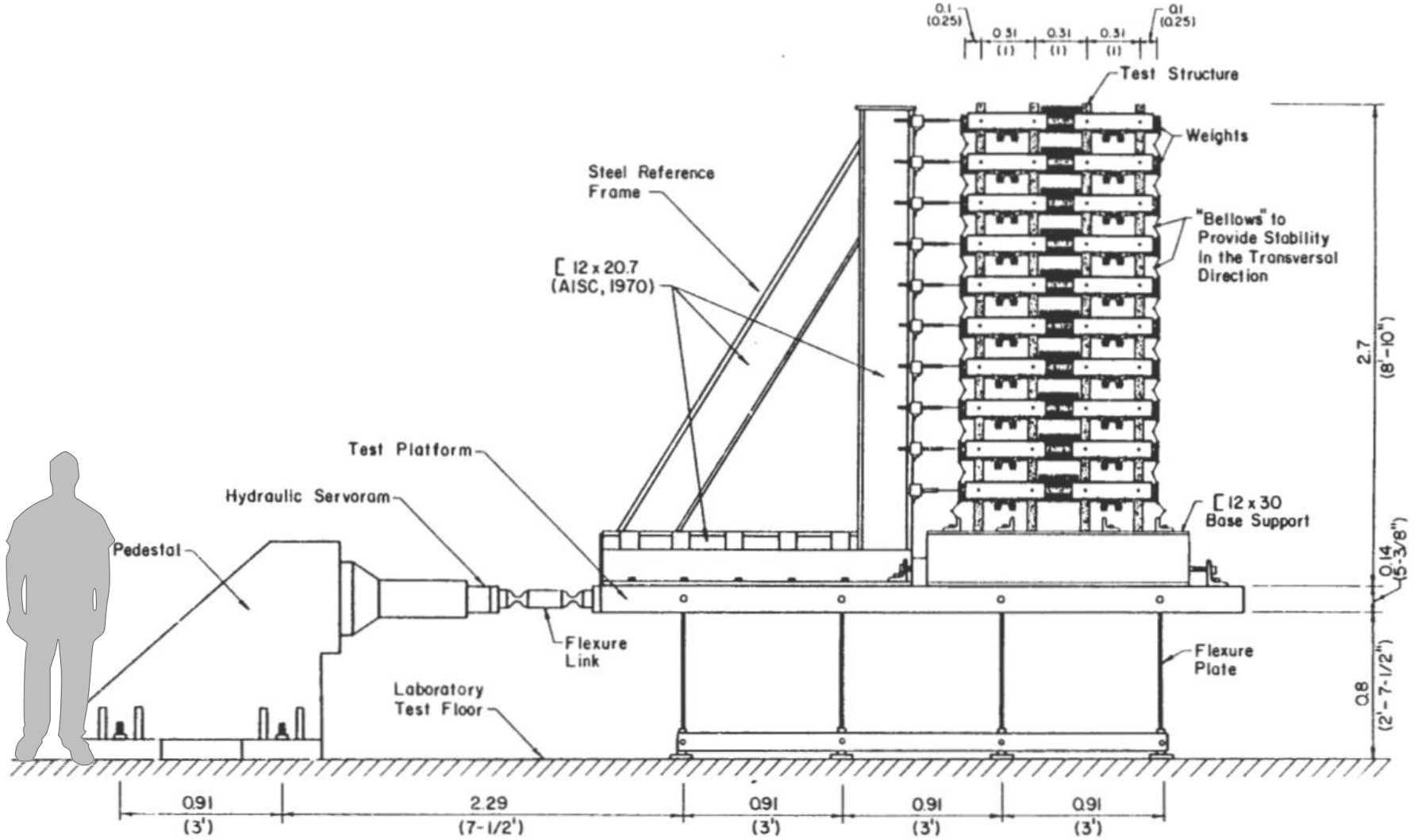
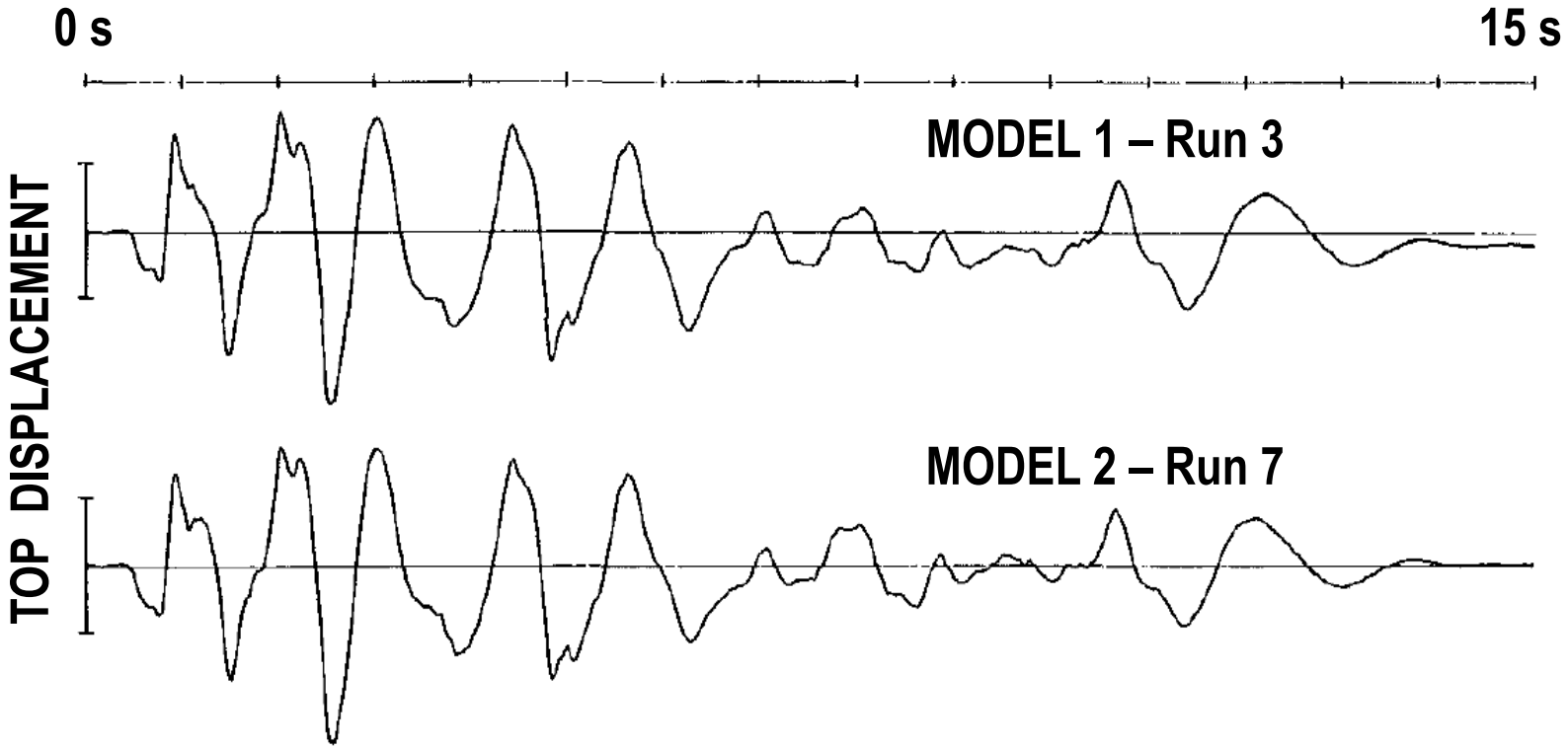
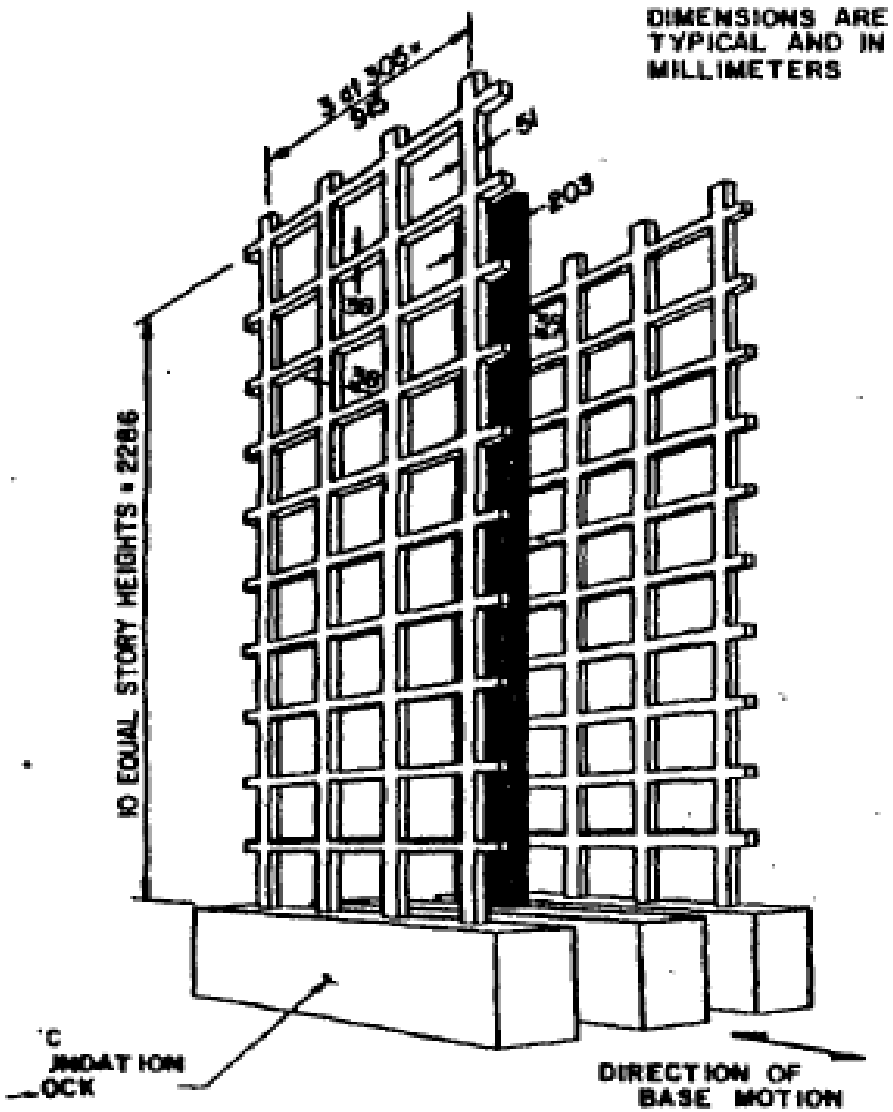
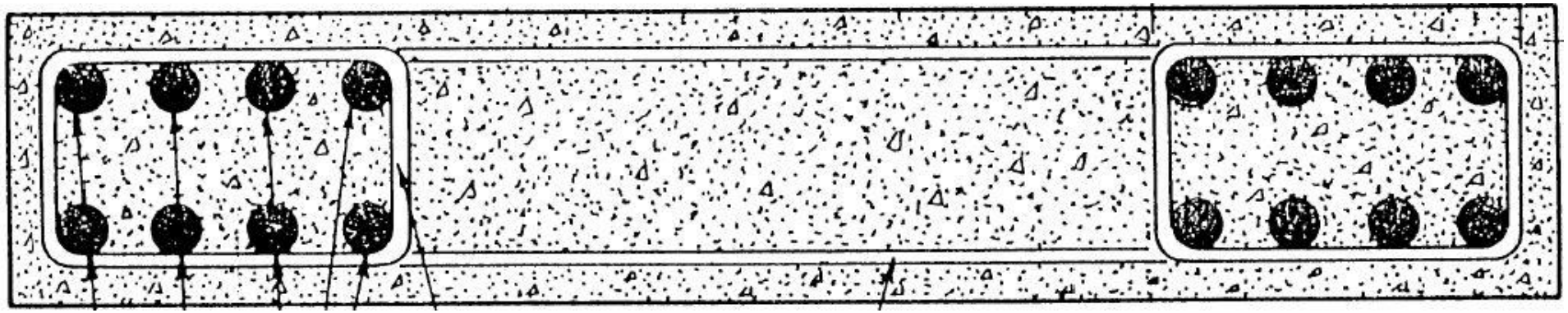


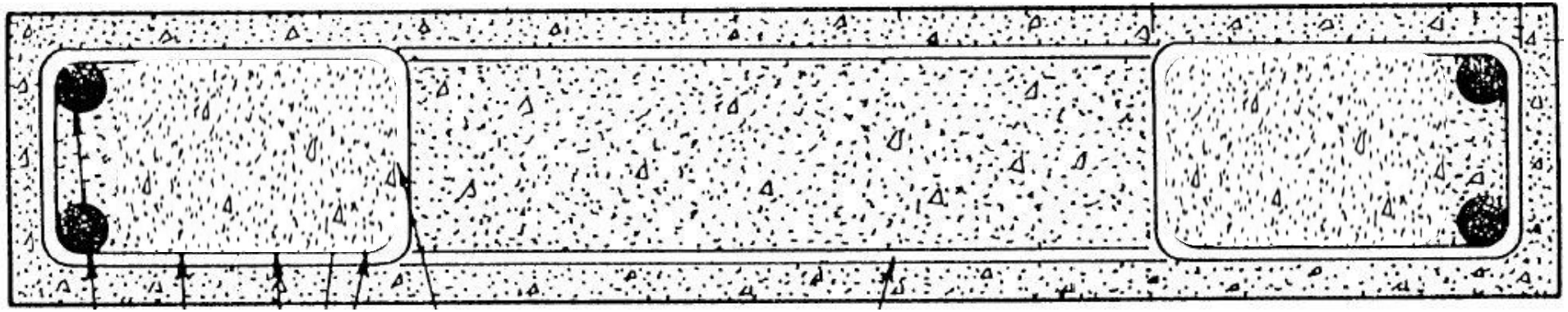
Fig. 3.1 General View of the Test Setup

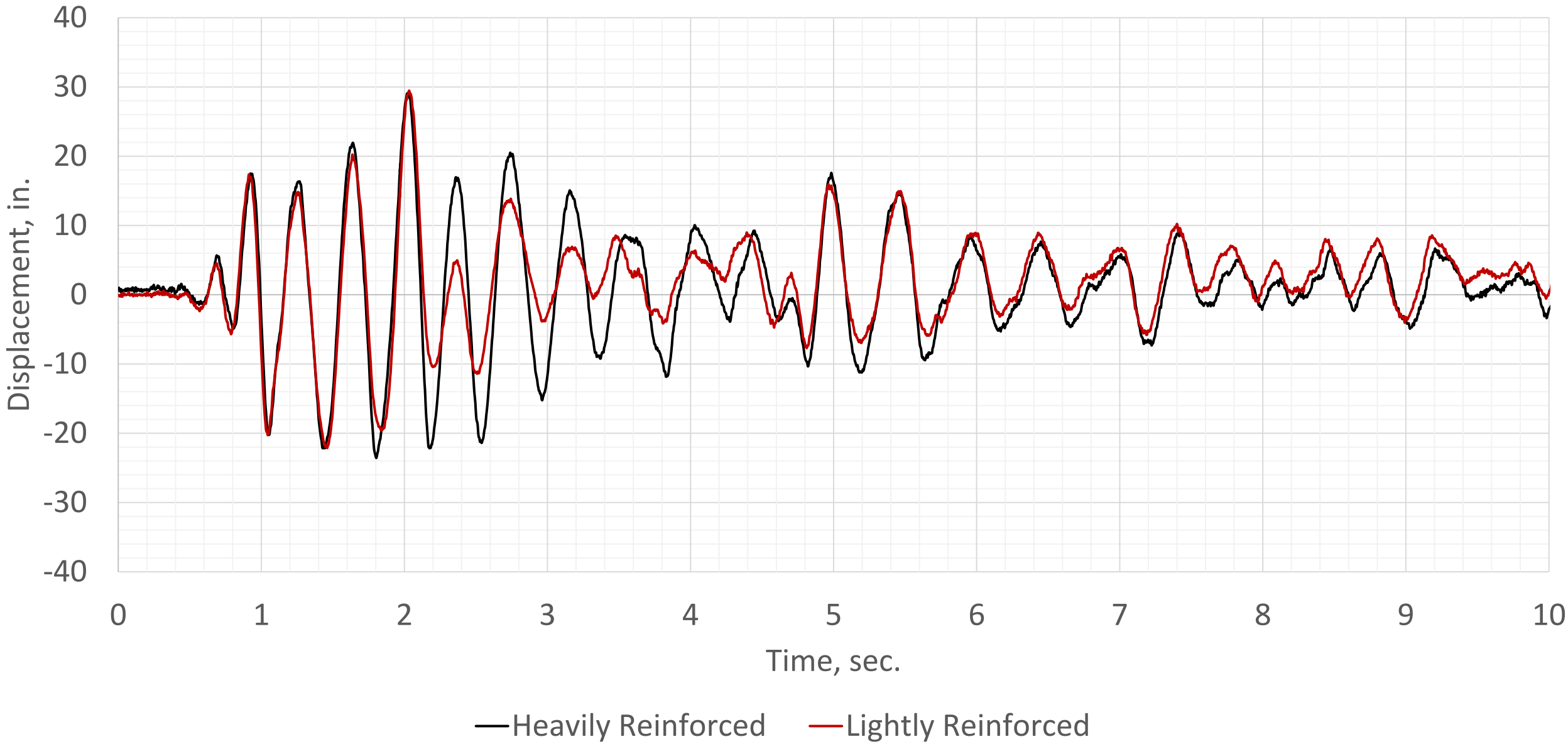

0 s
15 s
MODEL 1 – Run 3
MODEL 2 – Run 7
TOP DISPLACEMENT


DIMENSIONS ARE TYPICAL AND IN MILLIMETERS
3 @ 305 = 915
51
203
10 EQUAL STORY HEIGHTS = 2286
DIRECTION OF BASE MOTION

1979






40
30
20
10
0
-10
-20
-30
-40
Displacement, in.
0
1
2
3
4
5
6
7
8
9
10
Time, sec.
Heavily Reinforced
Lightly Reinforced

About strength

- “the structure generates the forces it can”

- “it is not loaded but it loads itself”

- “the stronger it is the larger are the …loads that may develop”

- “the engineer …not the earthquake, determines the magnitude of the …forces”


Sozen, M.A. 1981 "Review of Earthquake Response of Reinforced Concrete Buildings with a View to Drift Control", State of the Art in Earthquake Engineering Istanbul, Turkey

- Tests resulted in an effectively linear relationship between maximum displacement (…a measure of damage) and Housner … intensity.

- Tests resulted in an effectively linear relationship between maximum displacement (…a measure of damage) and [PGV].

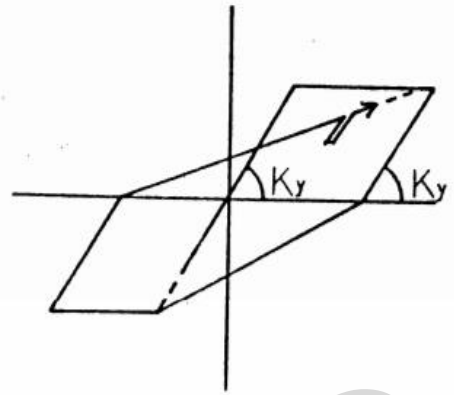
- maximum displacement could be correlated …with… period …using linear spectra

- … structures with substantially different quantities of … reinforcement … [had] comparable displacement

- “Cross wrote ‘… strength is essential but otherwise unimportant’”
- “The same statement may be made about ductility...”

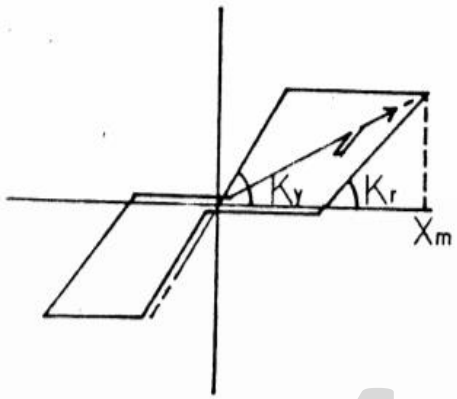
SHIMAZAKI

1984



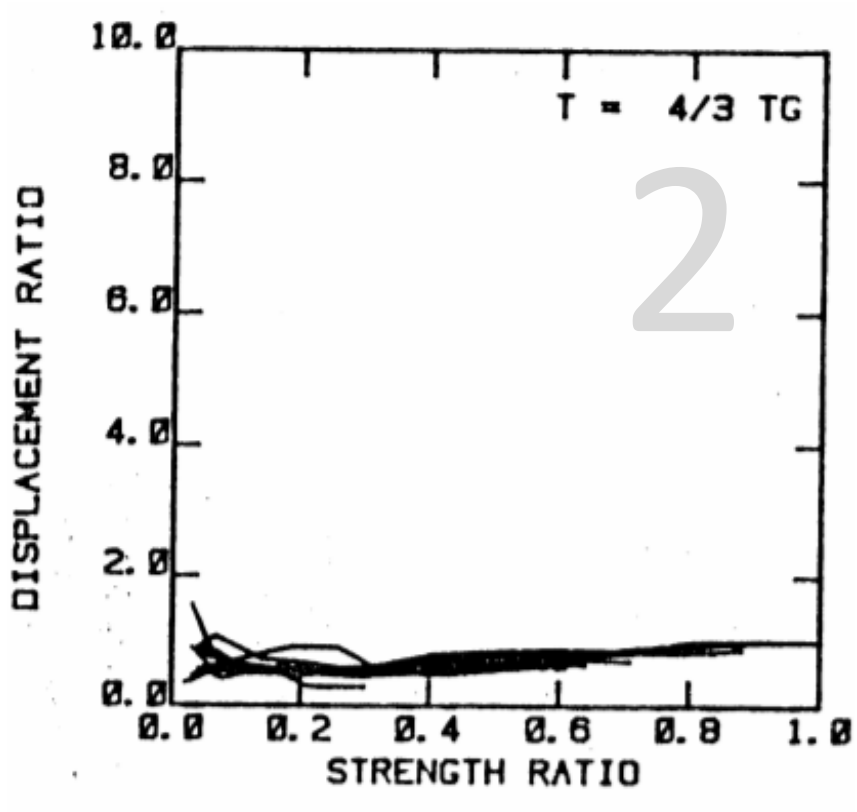
MODEL 2

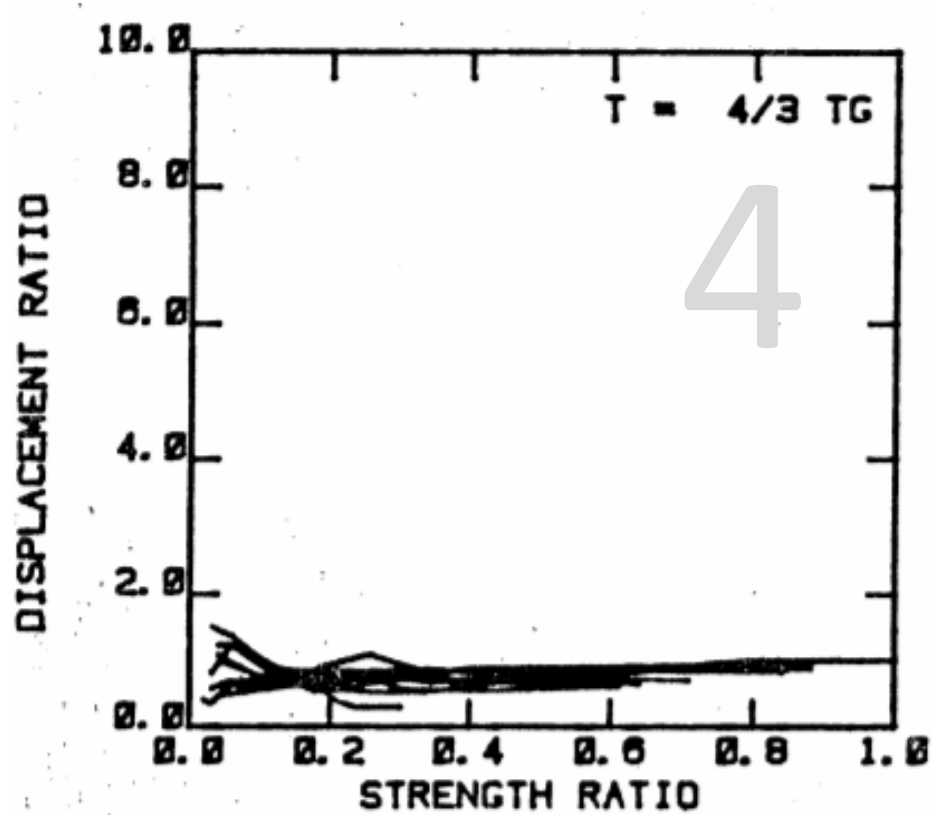
2



MODEL 4

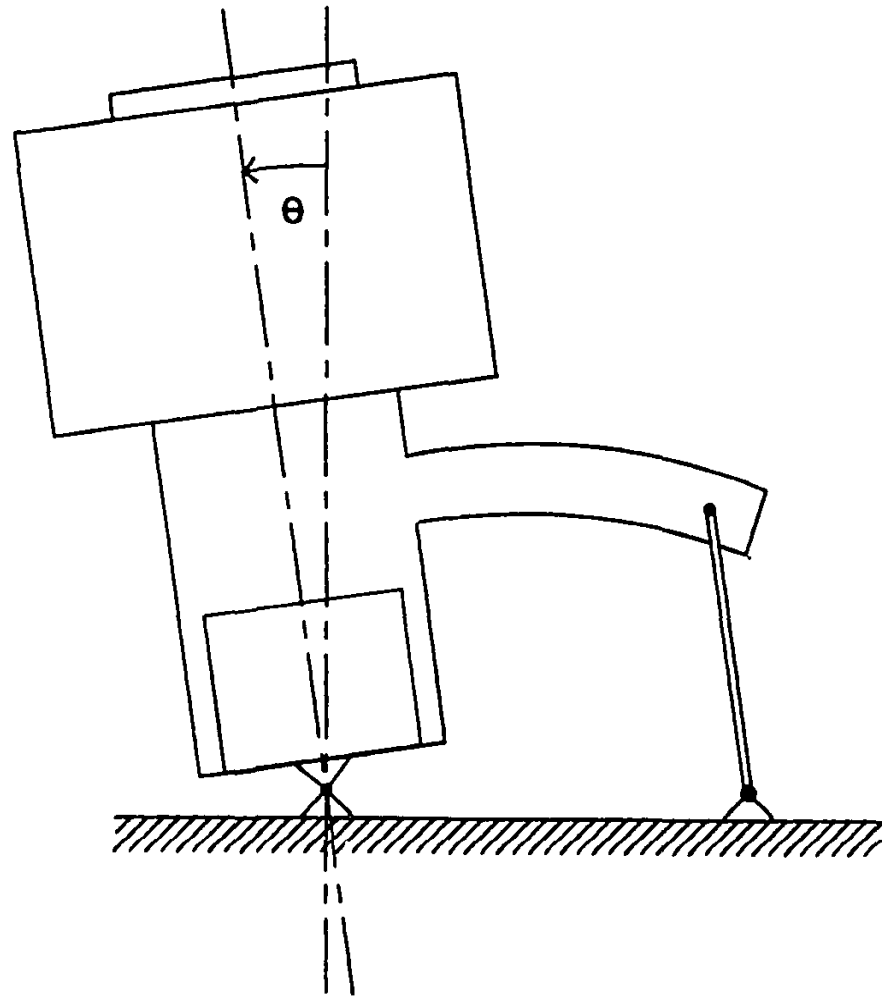
4


T = 4/3 TG
2
DISPLACEMENT RATIO
STRENGTH RATIO
10.0
8.0
6.0
4.0
2.0
0.0
0.0
0.2
0.4
0.6
0.8
1.0


T = 4/3 TG
4
DISPLACEMENT RATIO
STRENGTH RATIO
10.0
8.0
6.0
4.0
2.0
0.0
0.0
0.2
0.4
0.6
0.8
1.0

BONACCI

1989


θ

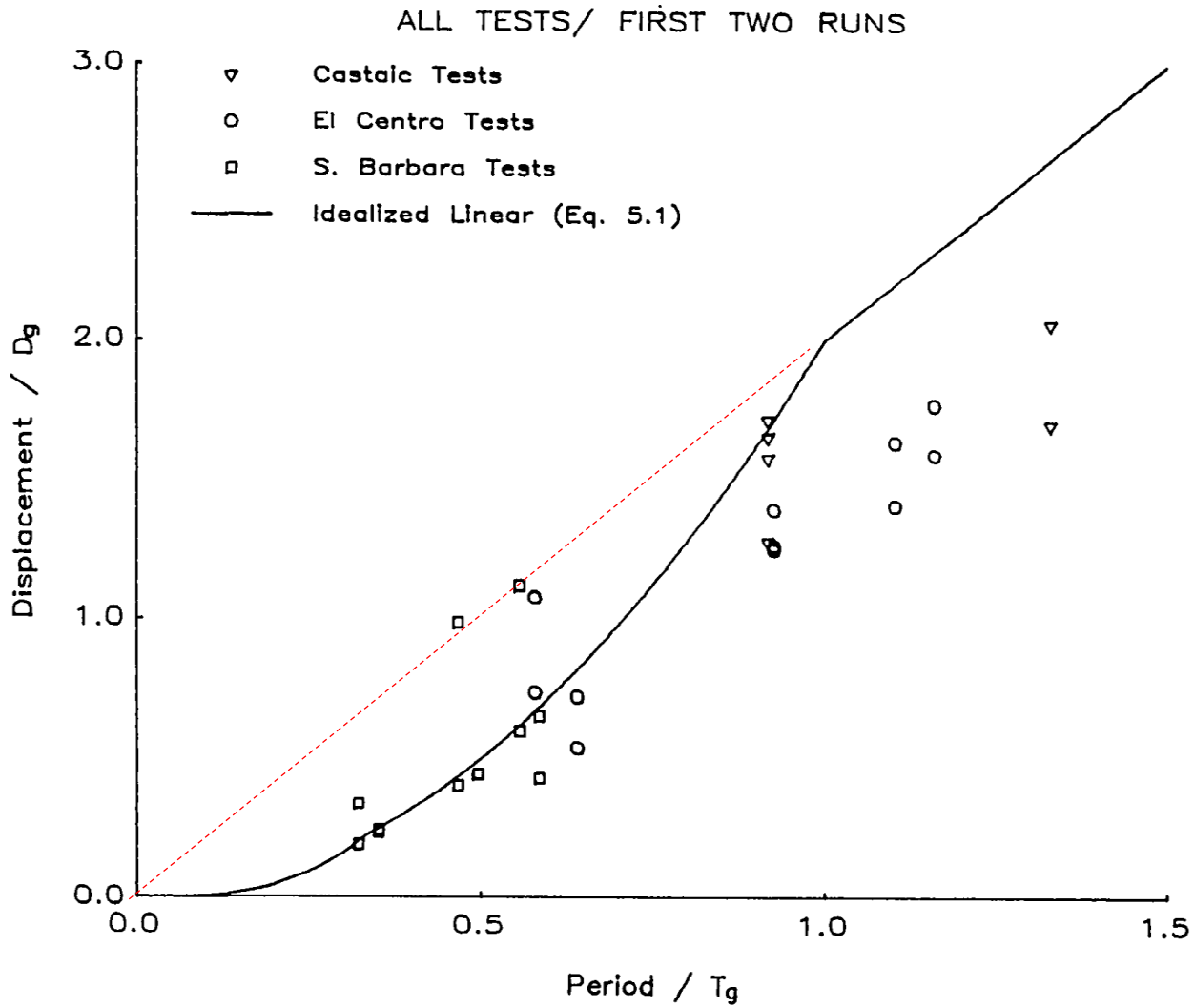


Fig. 5.4 Comparison of Normalized Test Results with Idealized Linear Spectrum

VELOCITY OF DISPLACEMENT

2003

$$PGV \times F_v$$

$$PGV \times F_v \times \frac{T}{2\pi}$$

$$PGV \times F_v \times \frac{T}{2\pi} \times \sqrt{2}$$

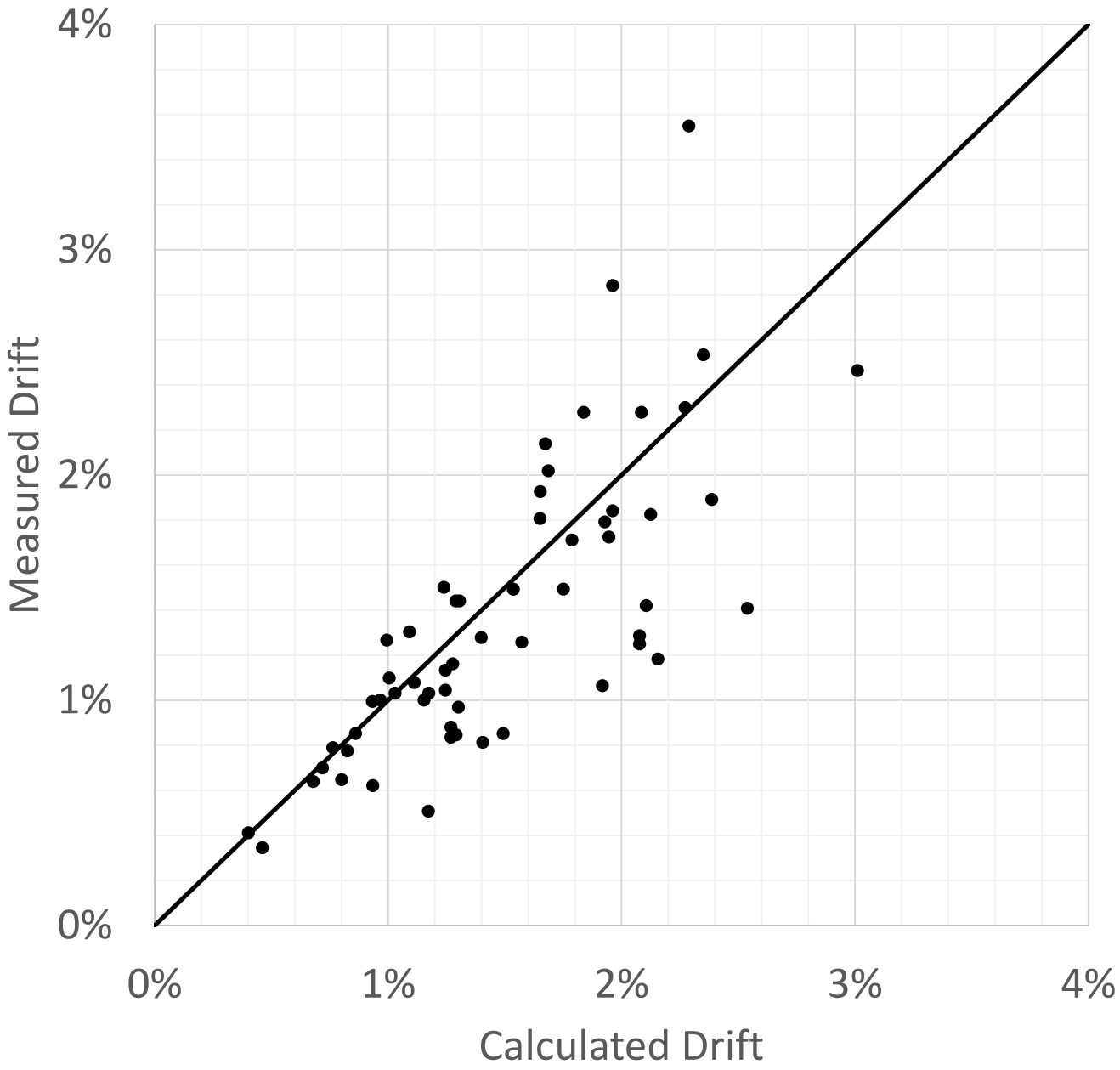
$$PGV \times F_v \times \frac{T}{2\pi} \times \sqrt{2} \times \Gamma$$

$$\Delta_{roof} = PGV \times F_v \times \frac{T}{2\pi} \times \sqrt{2} \times \Gamma$$

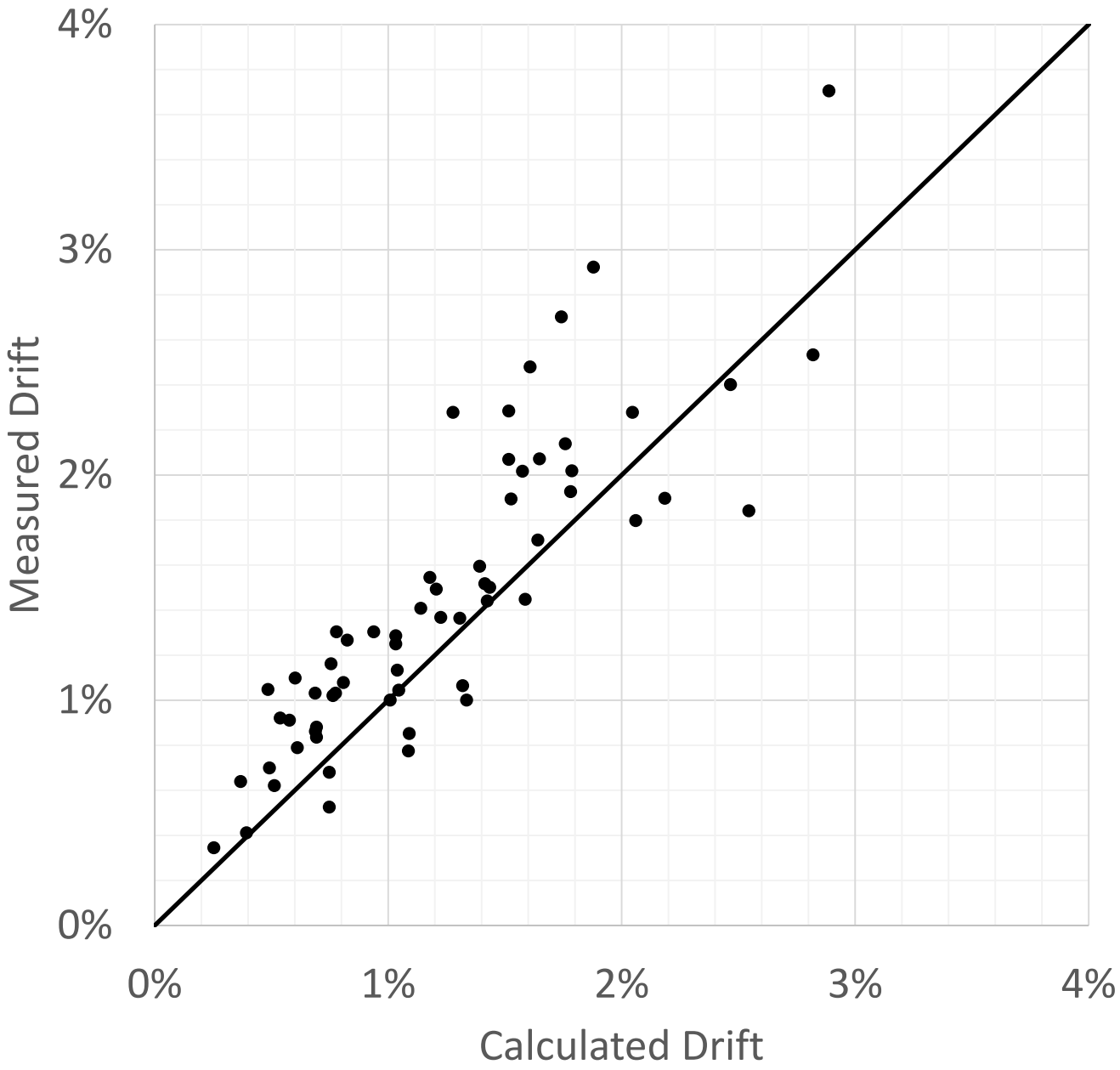
$$\Delta_{roof} = PGV \times \frac{T}{\sqrt{2}} \times \Gamma$$

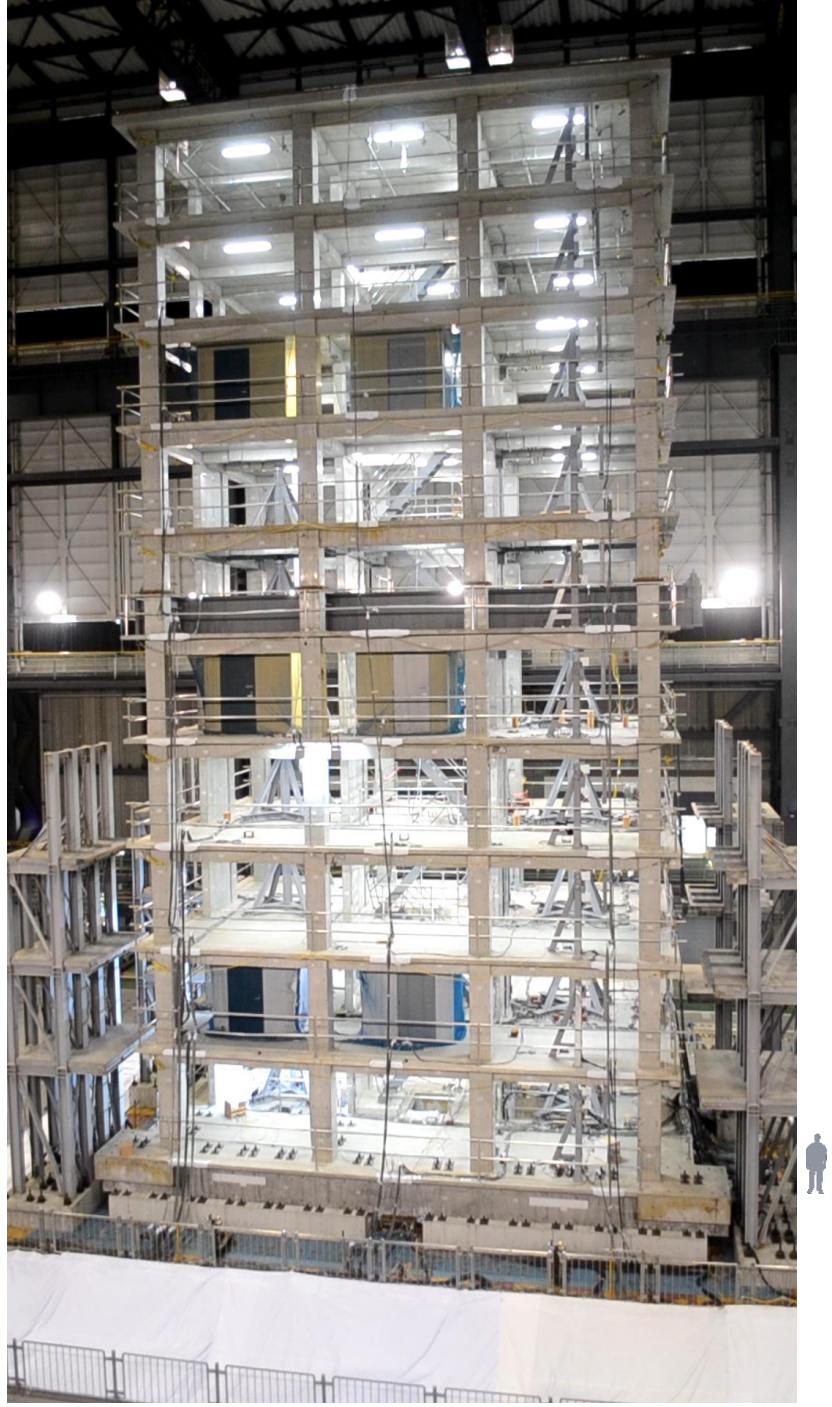
$$\Delta_{roof} = \sim PGV \times T$$

VOD



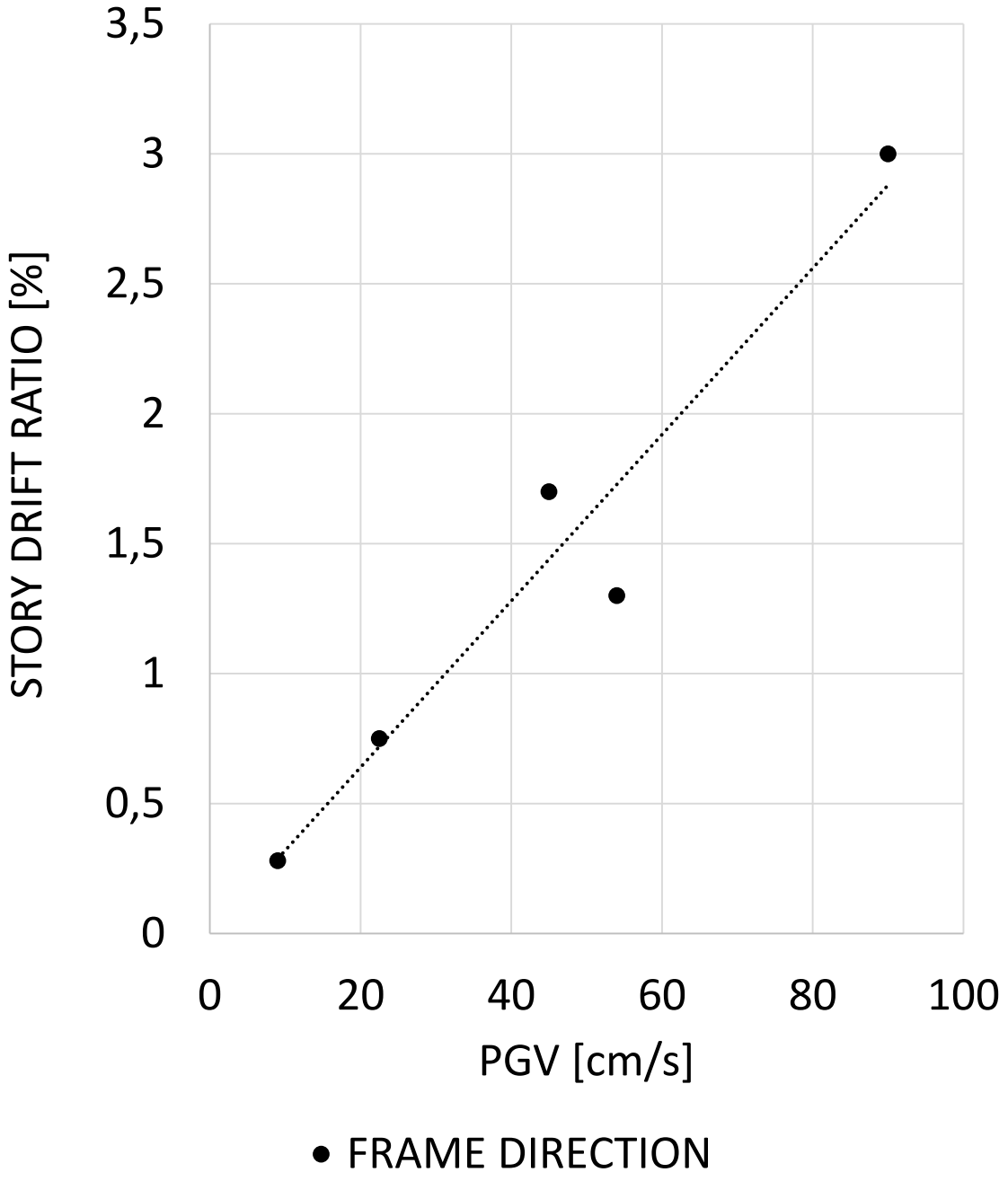
OpenSees

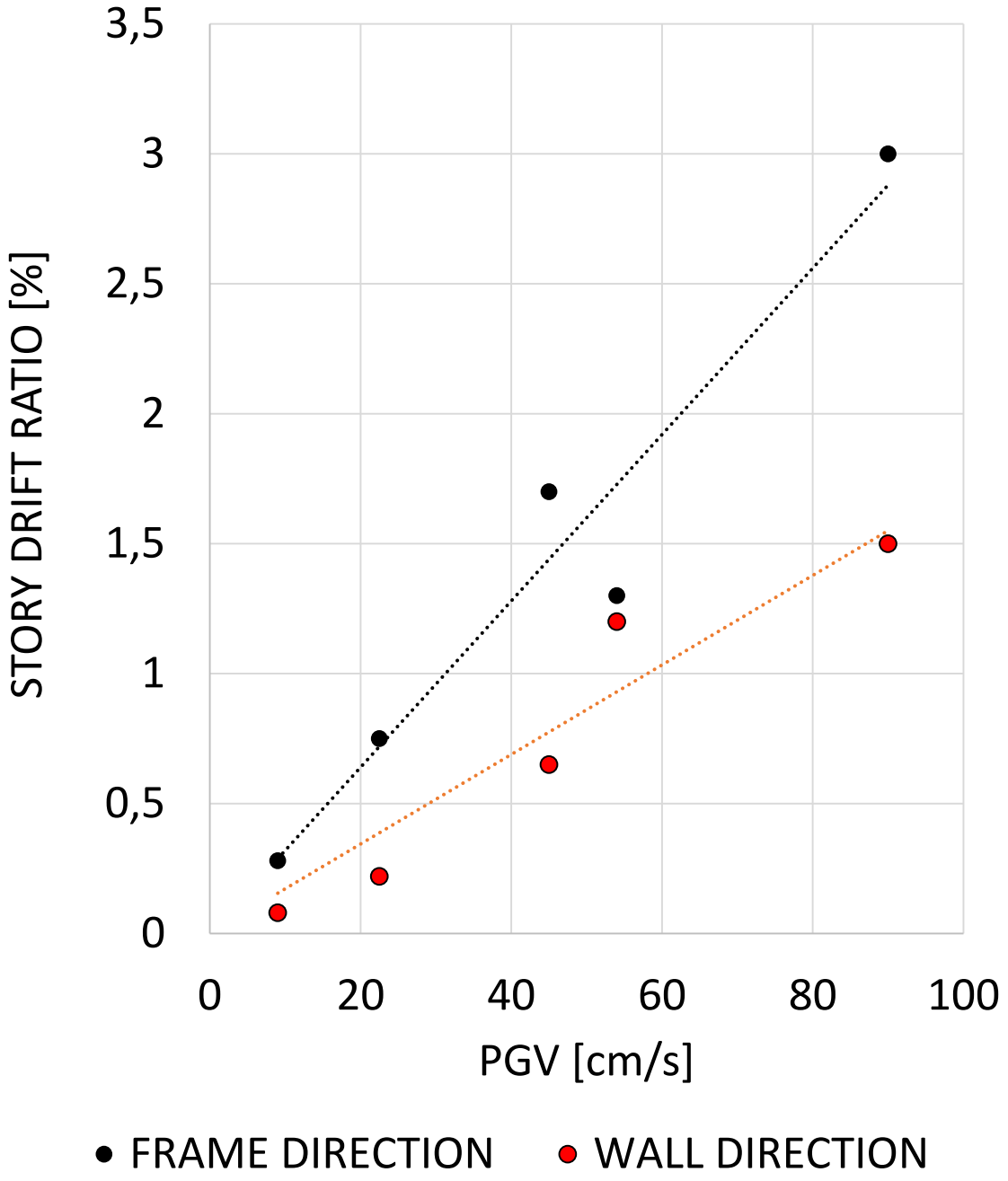




1. How far does it drift?

2. If ground motion intensity doubles does drift also double?


3,5
3
2,5
2
1,5
1
0,5
0
STORY DRIFT RATIO [%]
0
20
40
60
80
100
PGV [cm/s]
FRAME DIRECTION


3,5
3
2,5
2
1,5
1
0,5
0
STORY DRIFT RATIO [%]
0
20
40
60
80
100
PGV [cm/s]
FRAME DIRECTION
WALL DIRECTION

1. How far does it drift?
2. If ground motion intensity doubles does drift also double?
3. Would a second motion of similar intensity produce the same drift?
4. Would a second building with more reinforcement drift less?

It is not what I don’t know
what worries me

It is what I think I know
but ain’t so

M. Sozen