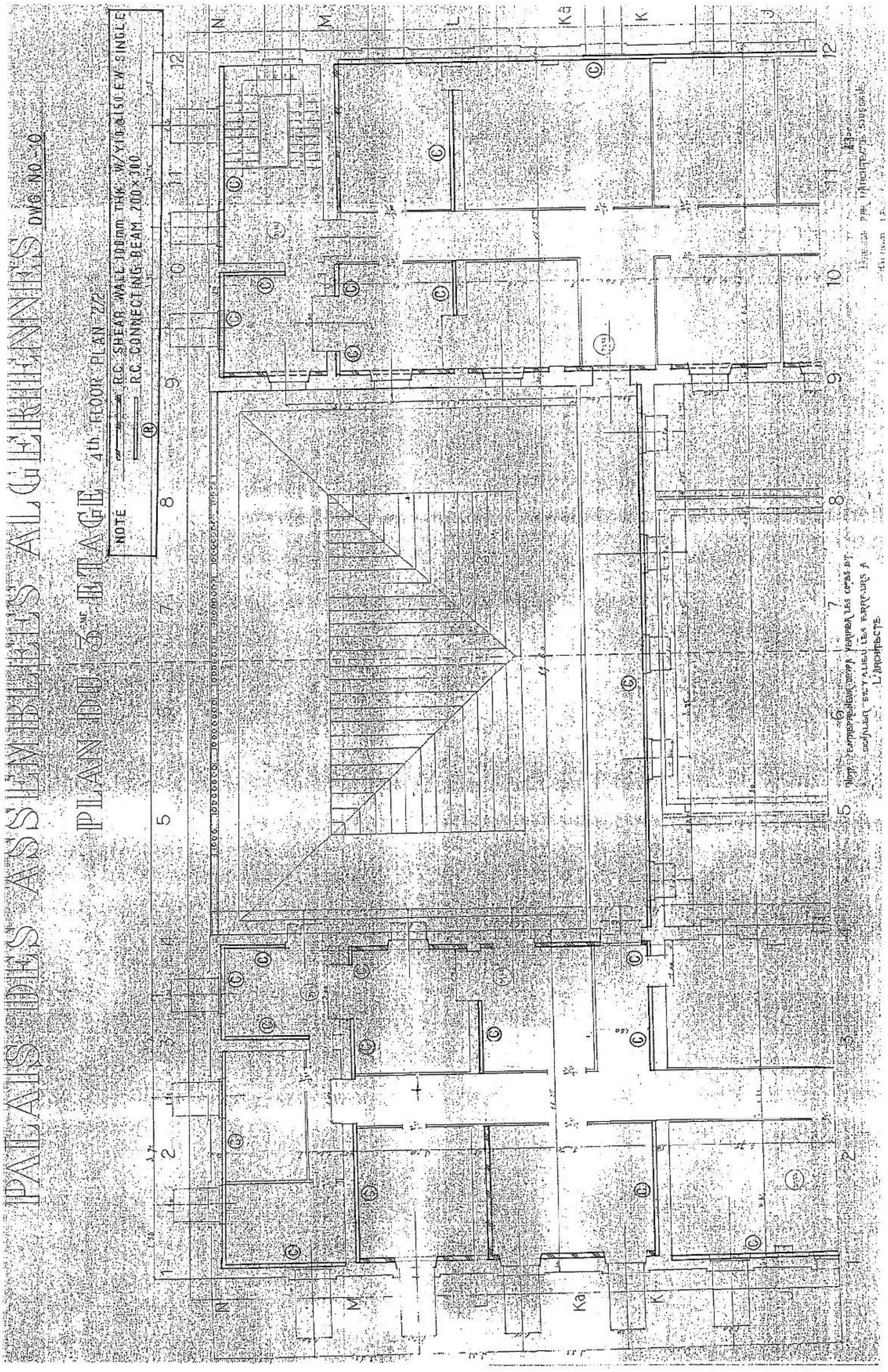

Figure 10-16 Retrofit Plan for the 4th Floor (2 of 2)

(B) (Option-1) Adoption of Seismic Isolation System at Basement Floor Level and 1st Floor Level

The seismic isolators with dampers are to be provided at the basement floor level and 1st floor level on the road-side only, and also approx. 60 cm to70 cm of clearance space around the under ground pit for the building movement during a great earthquake must be provided. Since the road-side columns have no additional space at ground level, the isolators for the road-side columns will be set at the upper part of the 1st floor columns as shown in Figure 10-17 and Figure 10-18.

Even if the base isolation system is adopted for all superstructure, the need for strengthening of the superstructure on each floor level must be checked to ensure the safety of the building. According to our seismic evaluation, only the portion from the 1st to the 2nd floor may require some strengthening.

Since the construction work, including setting of the seismic isolators is very sensitive, the instruction of special supervisors will be necessary.

The cost of this retrofitting work is quite high (in Japan, it is approximately 40% to 75% of the replacement cost).

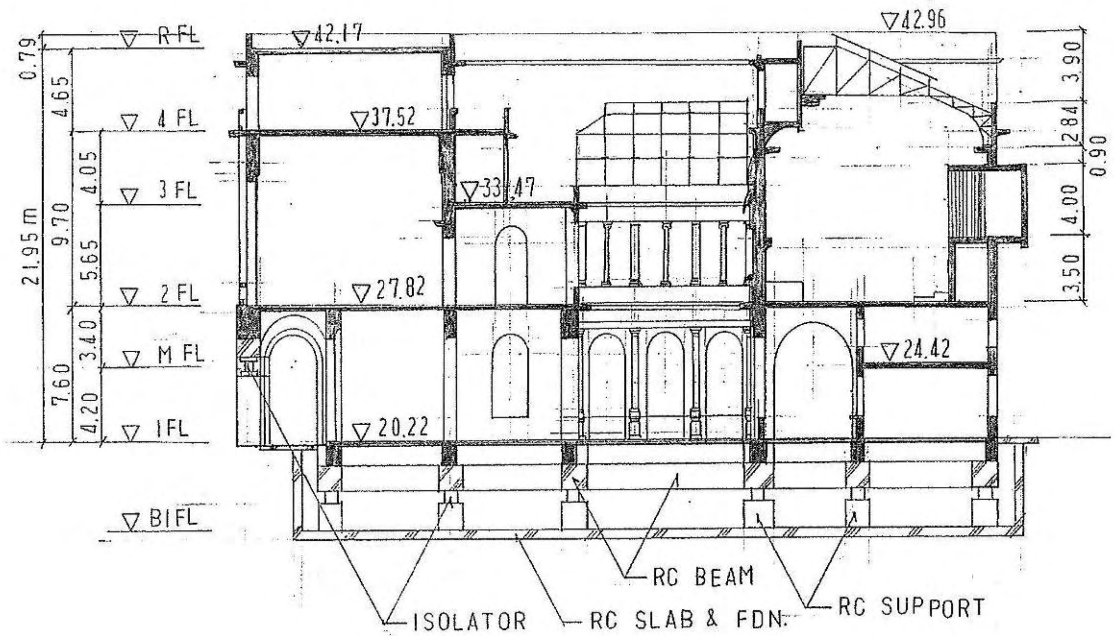

Figure 10-17 Elevation of the Seismic Isolator Installation

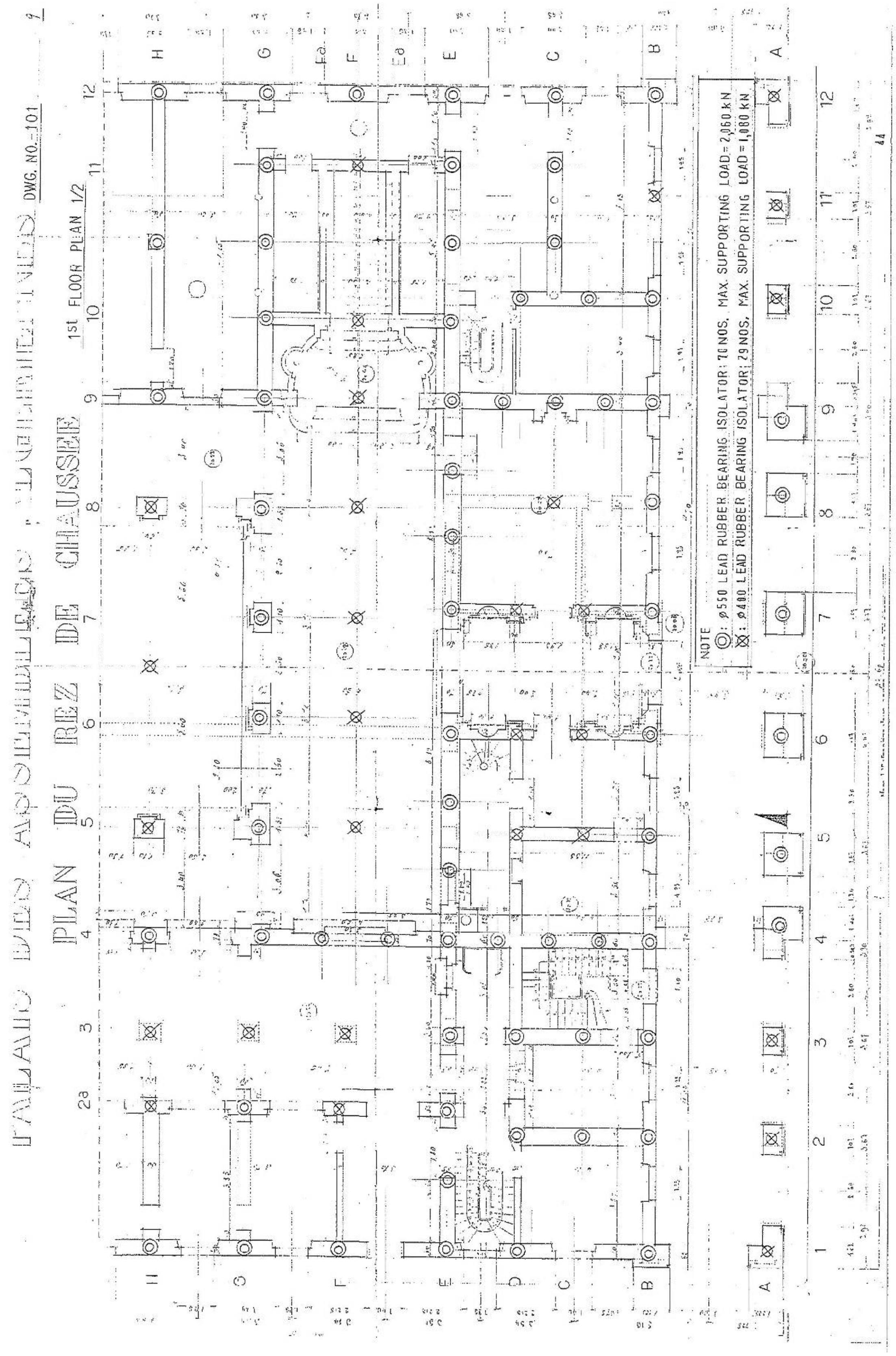

Figure 10-18 Layout of Seismic Isolators (1 of 2)

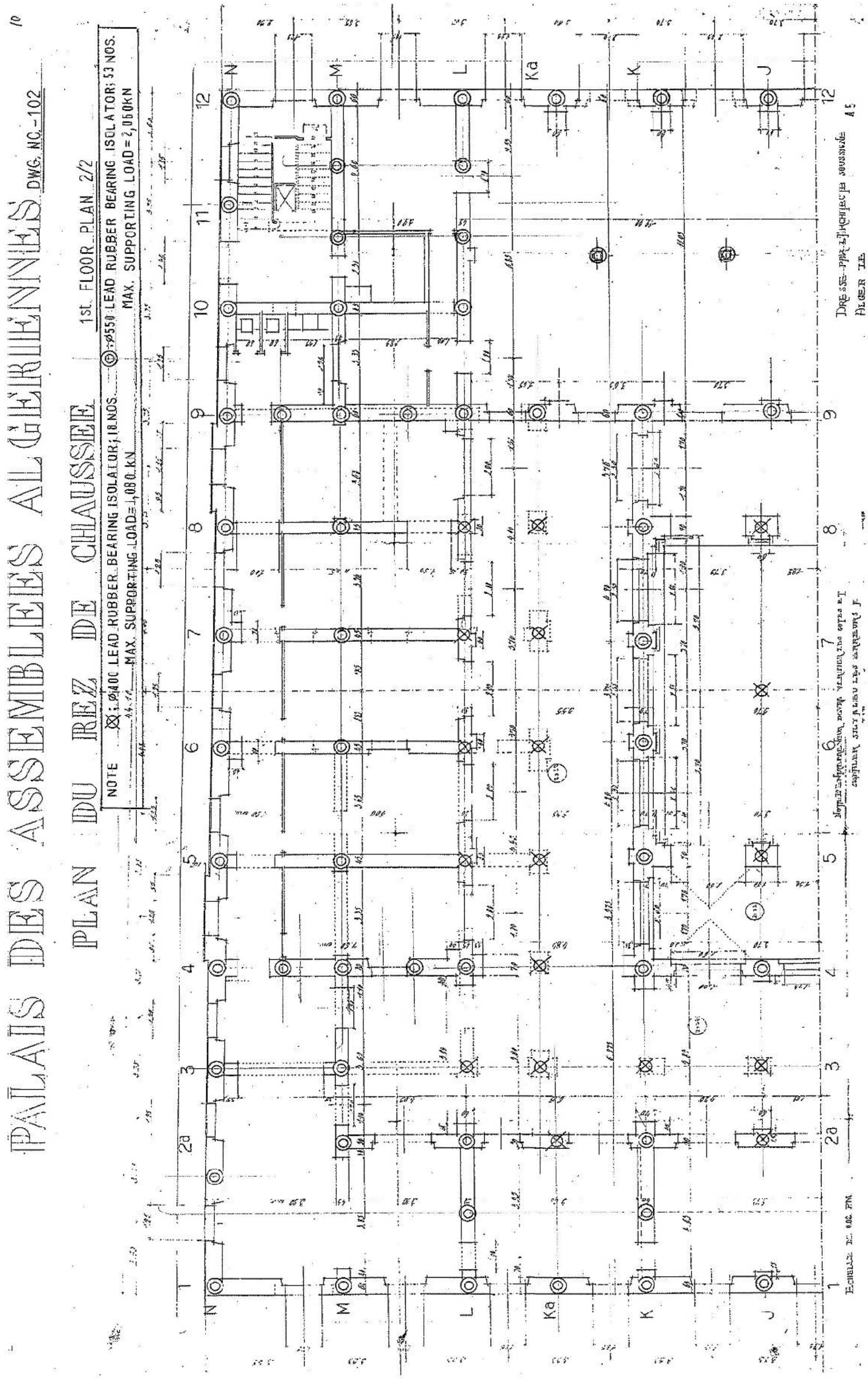

Figure 10-18 Layout of Seismic Isolators (2 of 2)

(C) (Option-2) Adoption of new RC Shear Walls plus the applying the Grouting Mortar Method to the Existing Bearing Walls

This method is used if there are cavities in the interior of the bearing walls due to the old masonry wall construction methods. The old method was to provide joint material (lime or clay mortar) to the outer portions of both sides of bearing walls, and to omit the joint material in the inner portion of thicker bearing walls. Accordingly, old thick bearing walls may have interior cavities. If it is learned during repair work that there are no cavities inside of the bearing walls this method can not be applied.

Grouting mortar is pumped in to all cavities inside of the existing bearing wall using a high pressure pump. The procedure for mortar grouting is shown in Figure 10-9 and Figure 10-10.

The grouting mortar compressive strength must be more than 25 N/mm^2. The effective shear strength for the design is assumed to be 25 N/mm^2 / 20 = 1.25 N/mm^2.

During mortar grouting work, the volume ratio of grouting mortar being injected per volume of bearing wall will be checked for each bearing wall every 3 to 5 m^2 of vertical surface area.

If during the above grouting mortar volume checks the volume ratio of grouting mortar being injected is found to be less than 10% of the volume of the bearing wall, the grouting work will be suspended, and the constructor will inform the engineer. In this case, the grouting mortar method for the subject wall is not viable.

If the volume ratio of grouting mortar being injected is more than 35% of the volume of the bearing wall, the grouting work will be suspended, and the constructor and the engineer will check for leakage of grouting mortar, and if any are found will take measures to provide an effective leakage stop. If the grouting mortar method is viable for the SENATE building, the cost of this retrofitting work is quite reasonable (in Japan, it is approx. 20% to 40% of replacement cost).

(D) (Option-3) Adoption of Grouting Mortar Method in to the Existing Bearing Wall

This method is used if there are cavities the as same as Option-2. If it was already determined that there were no cavities inside of the bearing walls during repair work, this method is not viable.

The grouting mortar method is adopted to strengthen the existing bearing walls. The grouting procedure is shown in Chapter 10-3-2 (2) (C).

The compressive strength of the grouting mortar must be more than 30 Mpa (N/mm^2) for walls from the 1st to 2nd floor, and more than 25 Mpa (N/mm^2) for walls on the 3rd and 4th floor.

If the grouting mortar method is viable for the SENATE building, the cost of this retrofitting work is quite reasonable (In Japan, it is approx. 25% to 45% of replacement cost).

2) Seismic Retrofit Design for Le SENAT

(A) Reinforced Concrete (RC) Shear Wall Method

For the recommended plan for the RC shear wall method applied to the existing bearing walls refer to Chapter 10-3-2 (3).

Required properties of the materials are as follows;

The required 28-day compressive strength of the concrete is more than 25 Mpa (N/mm^2) and the design shear strength is 2.0 Mpa (N/mm^2)

Tensile strength of reinforcing bar must be more than 400 Mpa (N/mm^2)

Total shear capacity of the existing bearing walls was calculated by following formula.

$$V \text{ exist.} = \tau_0 \, Wa$$

where;

$\tau_0 = 0.056$ Map (N/mm^2)

Wa: Sectional area of bearing wall in each direction ($m^2 = 10^6 \, mm^2$)

The charged shear force for the new RC shear walls was calculated by following formula.

$$V \text{ req.} = 0.304 \, F \, W - \tau_0 \, Wa$$

$$\text{Req. n Wa} = 1.10 \, (0.304 \times 1.15 \times W - 0.056 \, Wa) / 2.0$$

where;

V req.: The charged shear force for New RC shear walls

F: Safety factor = 1.15

Req. n Wa: Required sectional area of New RC shear walls

1.10: 10% of margin in design

Required sectional area of the new RC shear walls was calculated as shown in Table 10-24.

Table 10-24 Required Sectional Area of New RC Shear Walls

Place		A = 0.304 F W (10^6 N)	B = 0.056 W (10^6 N)	A – B (10^6 N)	Req. n Wa (m^2)	Shear Wall (thk.) , Length
Story	Direct.					
4th FL	X	11.11	6.71	4.40	2.4	(0.10m), 24 m
	Y		5.14	5.97	3.3	(0.10m), 33 m
3rd FL	X	21.79	8.28	13.51	7.4	(0.15m), 50 m
	Y		6.71	15.08	8.3	(0.15m), 56 m
2nd FL	X	36.10	8.93	27.17	15.0	(0.20m), 75 m
	Y		7.33	28.77	15.8	(0.20m), 79 m
Mezzanine FL	X	49.22	10.04	39.18	21.6	(0.20m), 108 m
	Y		10.74	38.48	21.2	(0.20m), 106 m
1st FL	X	62.04	10.47	51.57	28.4	(0.20m), 142 m
	Y		11.39	50.65	27.9	(0.20m), 140 m