

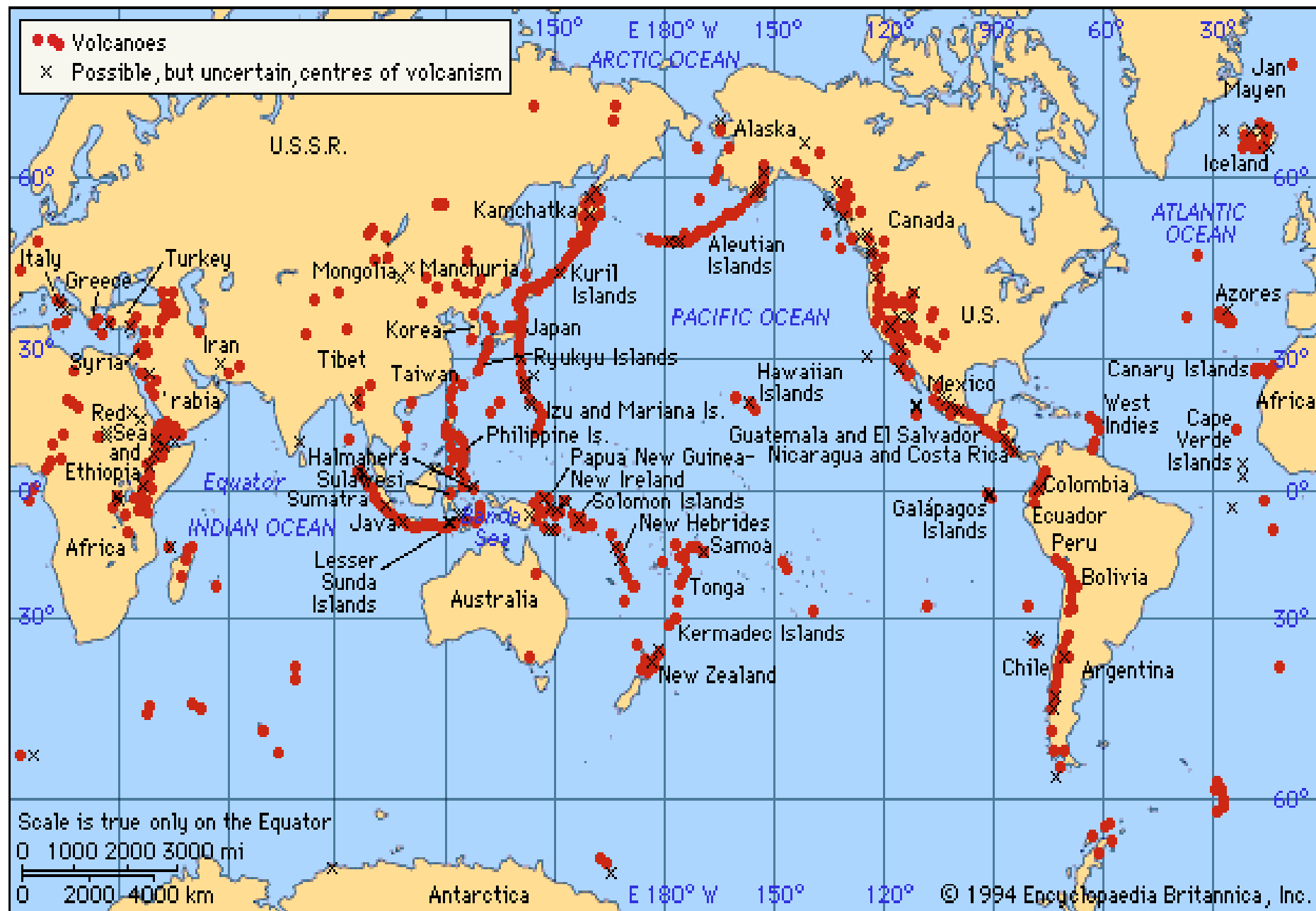
What Happen to Underground during Earthquake

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Effects of Earthquake on Underground Structures

- What should we learn from Earthquakes in other countries, e.g. Kobe, Taiwan, and Singapore
- Investigation results on damages to underground structures due to the Earthquake
- How can we protect our underground structures from Earthquakes



Fault Zones Around the World

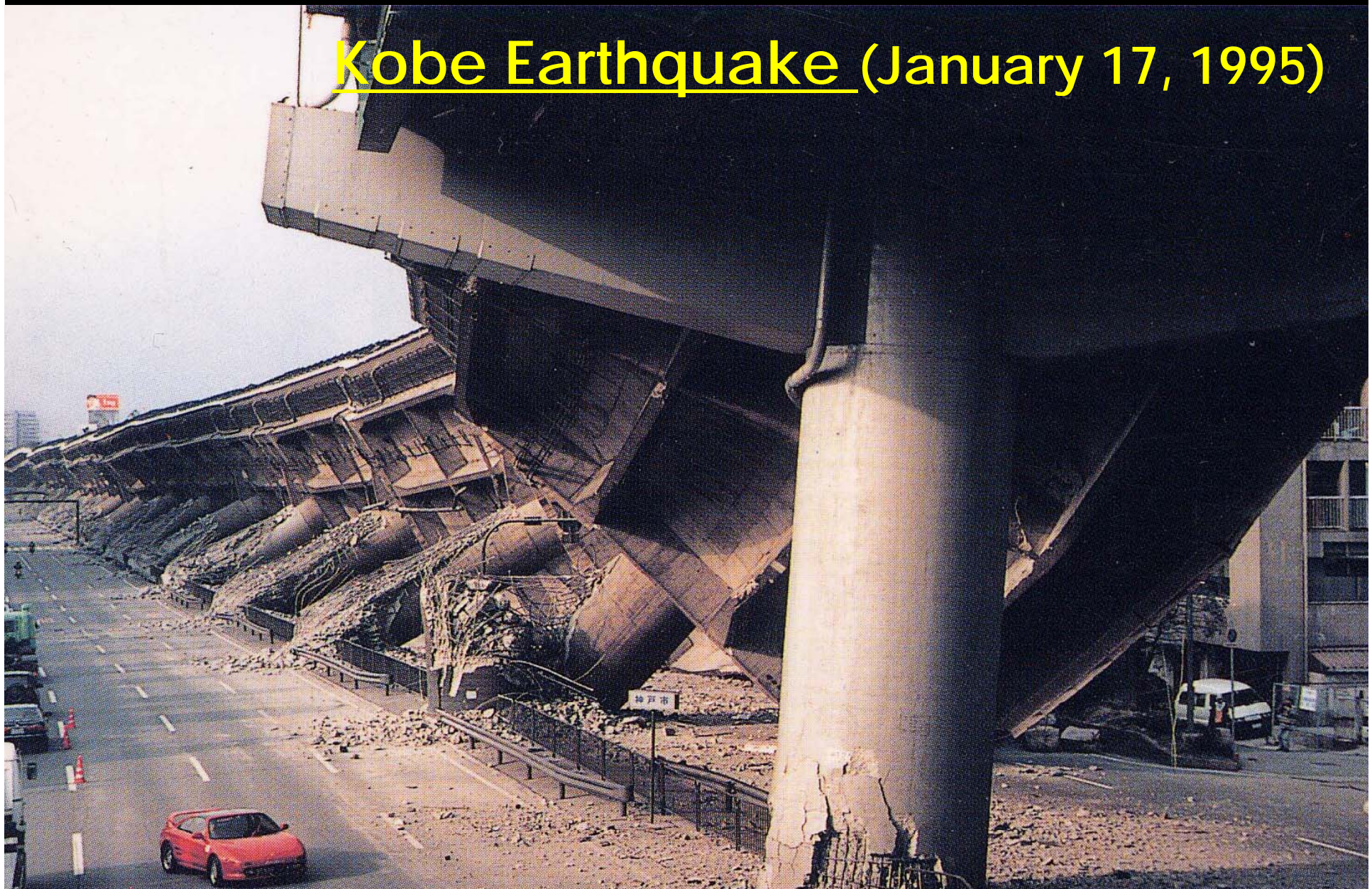
Taiwan Earthquake (September 21, 1999)







Kobe Earthquake (January 17, 1995)



Famous Picture of Collapsed Hanshin-Expressway

Investigation on Underground Structures After Kobe Earthquake

- (1) Daikai Station, Kobe Express Railway: completely destroyed
- (2) Kobe Station, Kobe Express Railway: unharmed
- (3) Sannomiya Station, Kobe City Subway, damaged
- (4) Kencho-Mae Station, Kobe City Subway, unharmed
- (5) Sanchika Underground Shopping Mall, unharmed

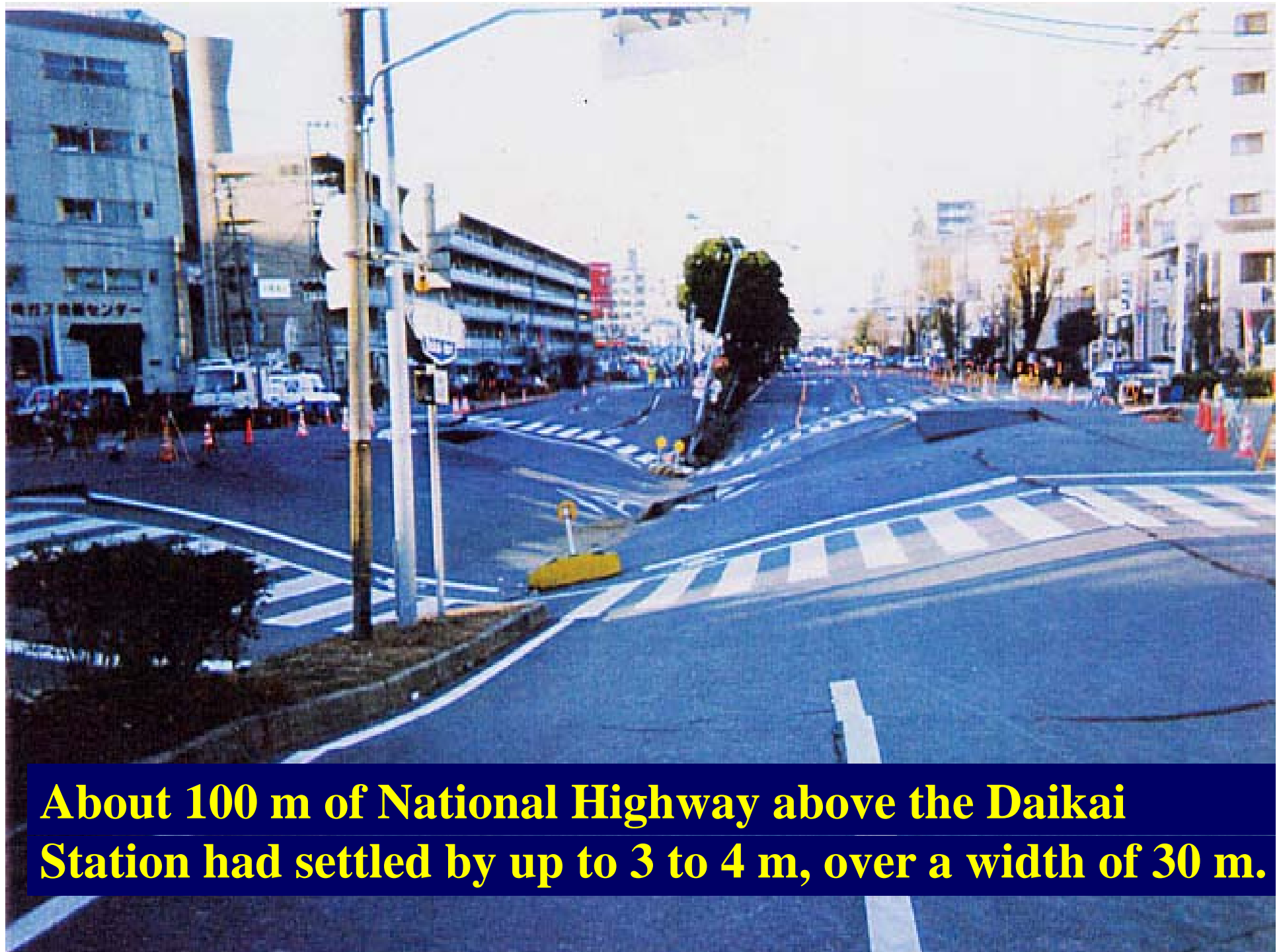
(1) Daikai Station : Kobe Express Railway

Completely destroyed

**70 cm in width x
45 cm in depth x
2.6 m height**



Destroyed RC pillar at center of B1 concourse floor



About 100 m of National Highway above the Daikai Station had settled by up to 3 to 4 m, over a width of 30 m.



View of reconstructed B2 floor of Daikai Station, center pillars made by composite structures of steel box and RC.

(2) Kobe Station: Kobe Express Railway, unharmed

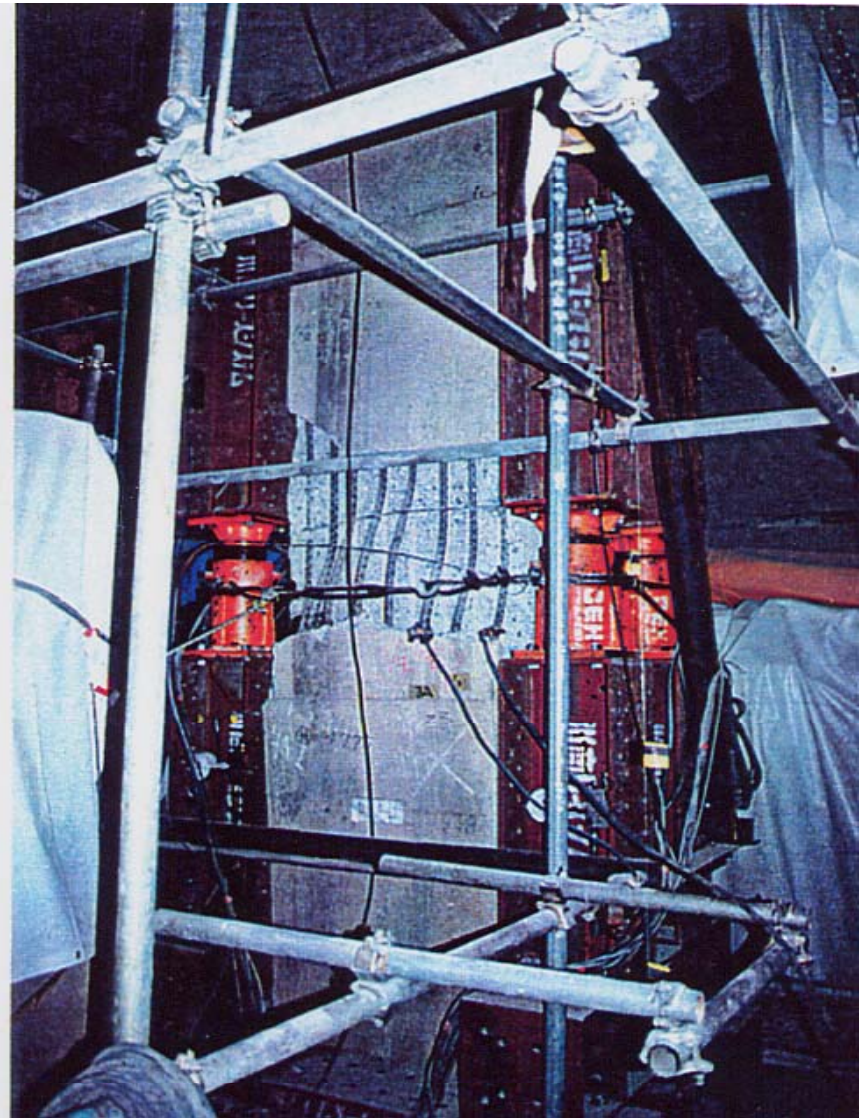
two island type platforms, 24 m wide, only one row of center steel pipe columns with 40 cm in diameter support structure



(3) Sannomiya

Station : Kobe city

subway



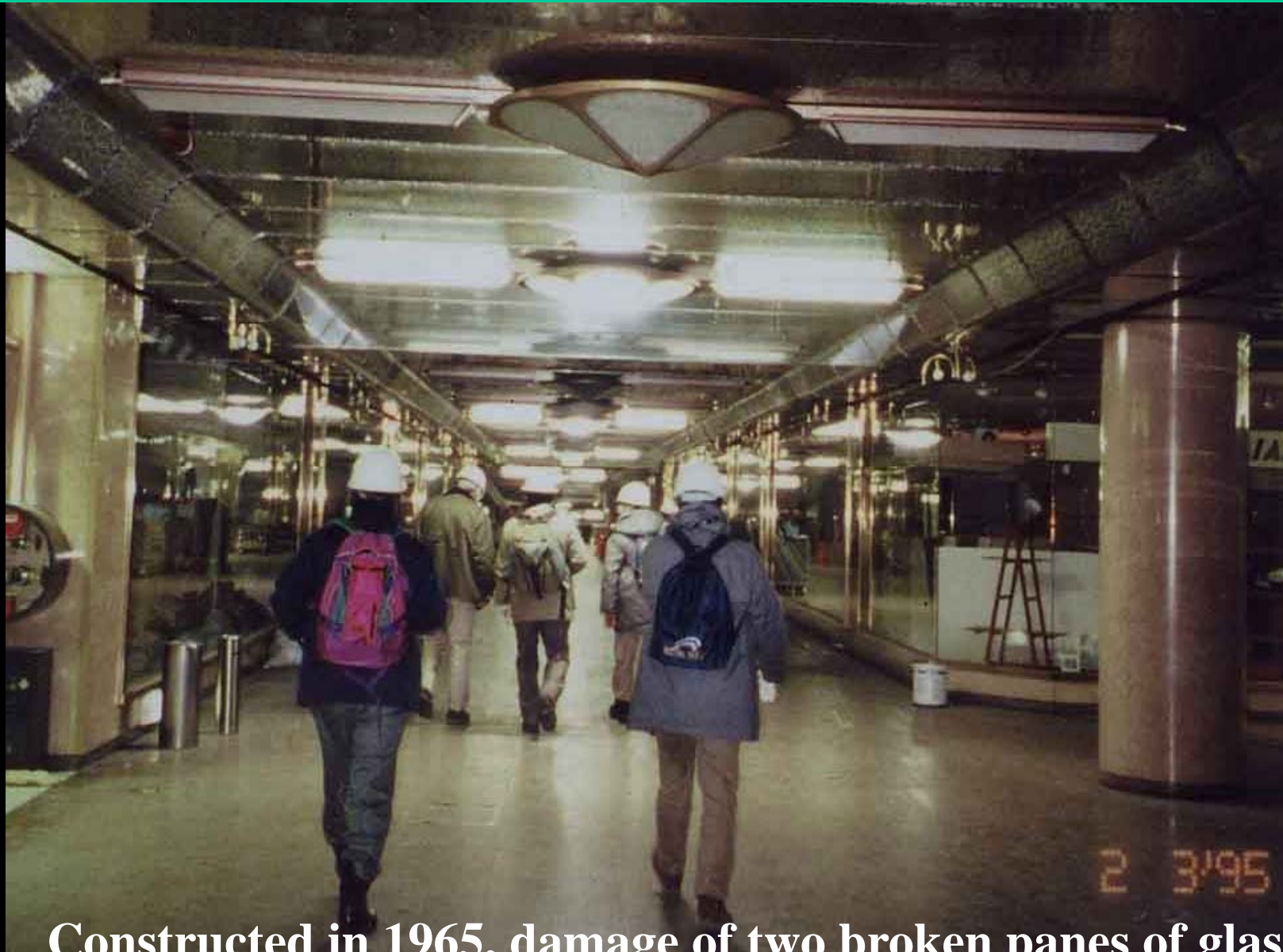
Damage of concrete pillars and temporary reinforcement to central pillars in machine room on B1 floor (Sannomiya Station).

(4) Kencho-Mae Station :Kobe City Subway, unharmmed



Exactly
similar
structure as
Sannomiya
Station

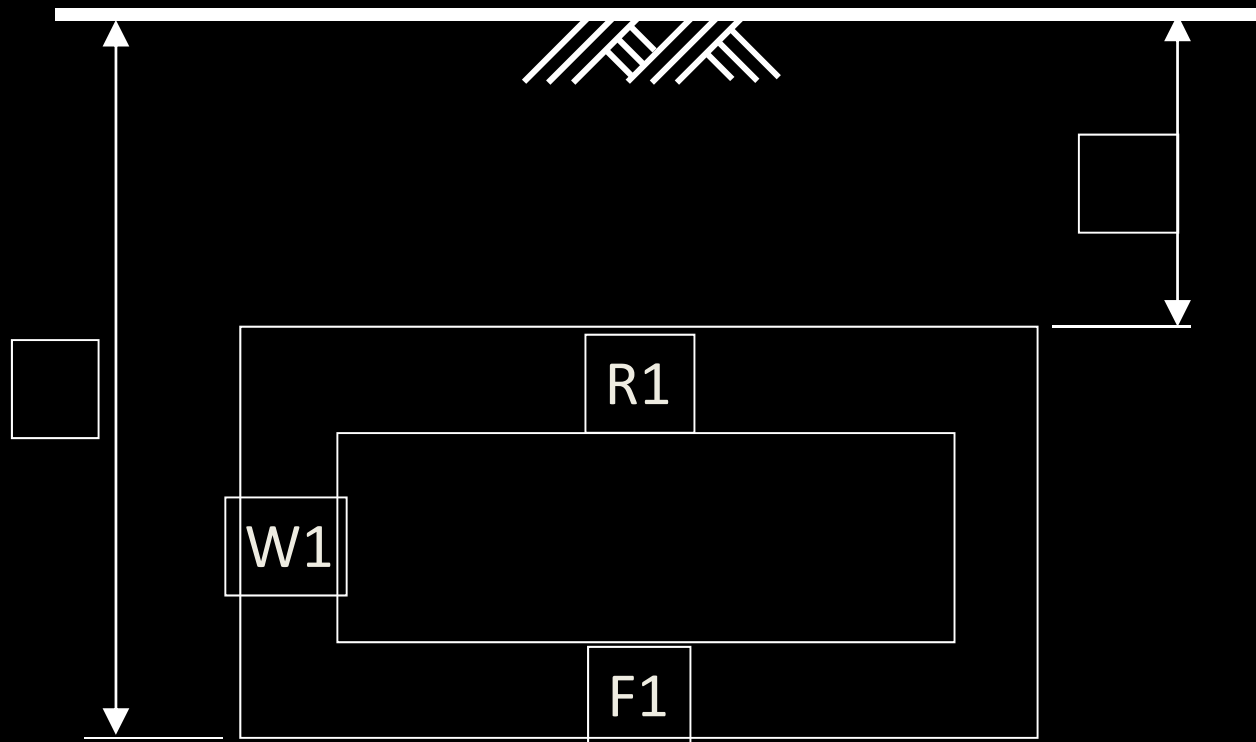
(5) Sanchika Underground Shopping Mall



Constructed in 1965, damage of two broken panes of glass..
Steel pipe pillars $\phi = 60$ cm

MRT Singapore

Civil Defence Shelter Requirements



$R1, W1 = 1.95\text{m}$ (minimum)

$T_f < 15\text{m} : F1 = 1.95\text{m}$ (minimum)

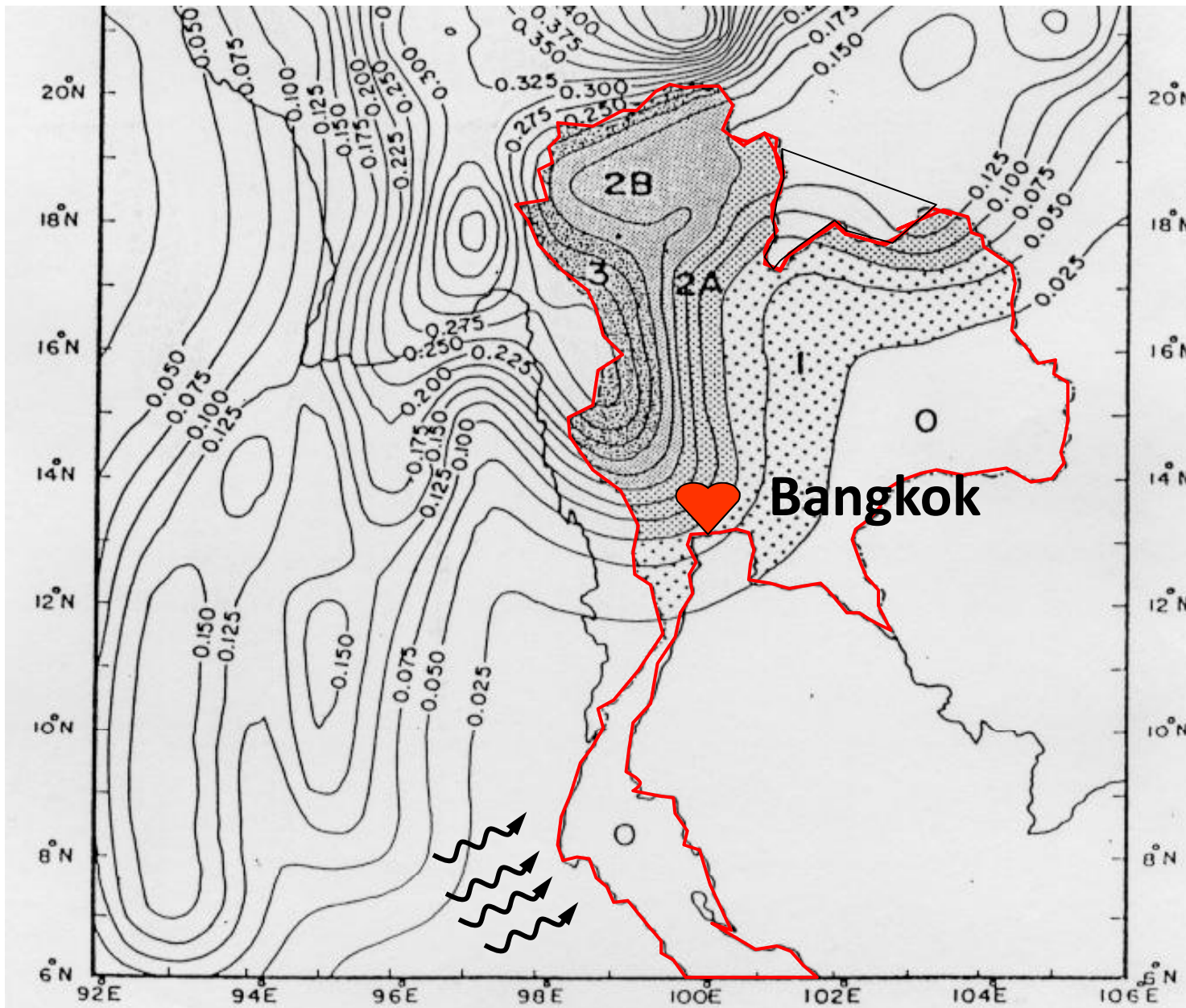
Tunnel Civil Defence Door - Peacetime



Tunnel Civil Defence Door – CD

Mode





We can
Suffer from
the Shake

- Area 3 High risk in suffering damage
- Area 2A and 2B High risk in suffering medium damage
- Area 1 Chances to suffering minor damage

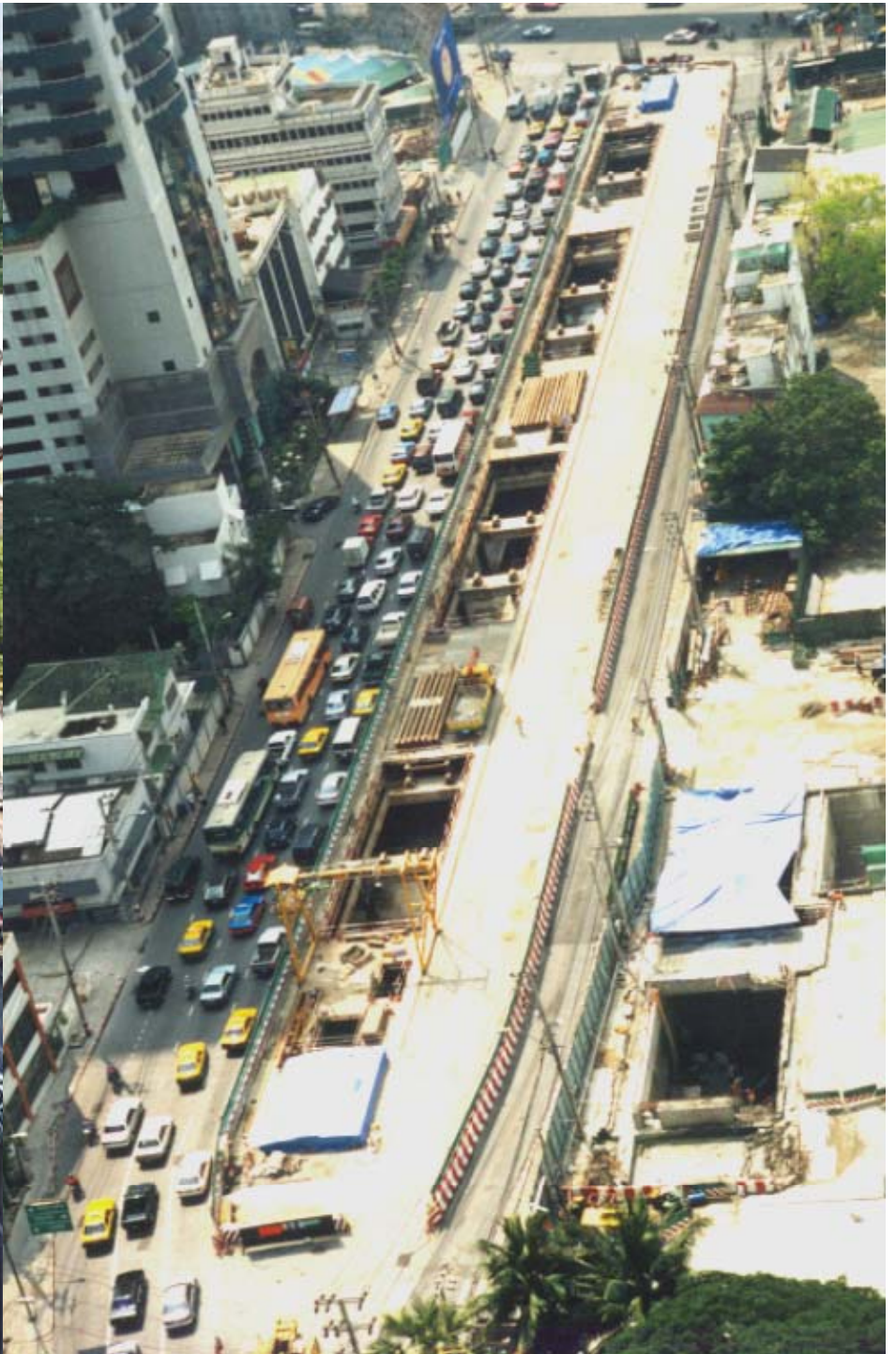
Effects of Earthquakes on MRTA Tunnel

1. Very low possibility that Serious Earthquake will occur in Bangkok.
2. But, it is possible that the Earthquake can damage above ground structures.
3. However, underground structures will suffer much less.

MRTA Underground and Extension

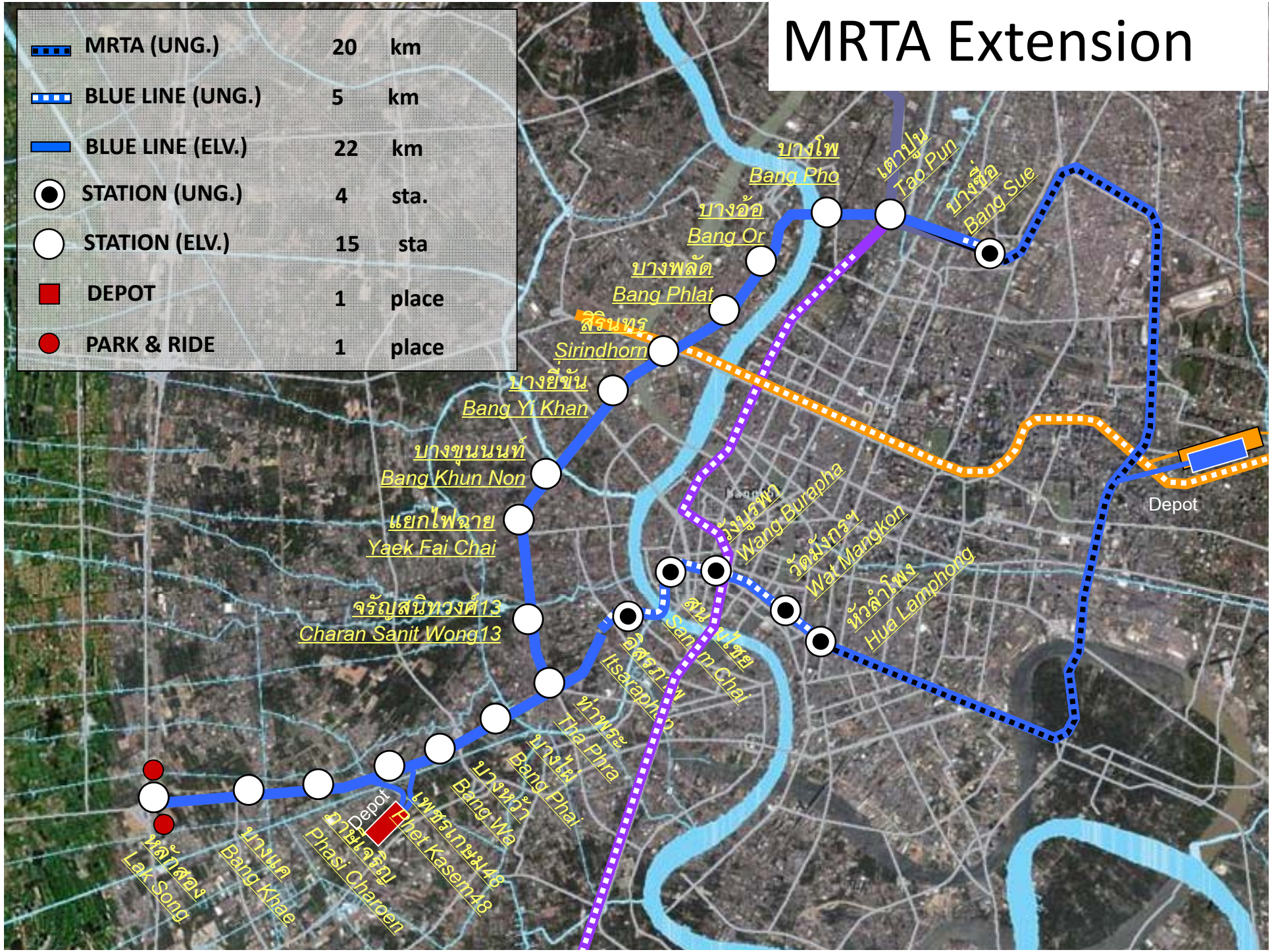
TYPICAL SUBWAY STATION

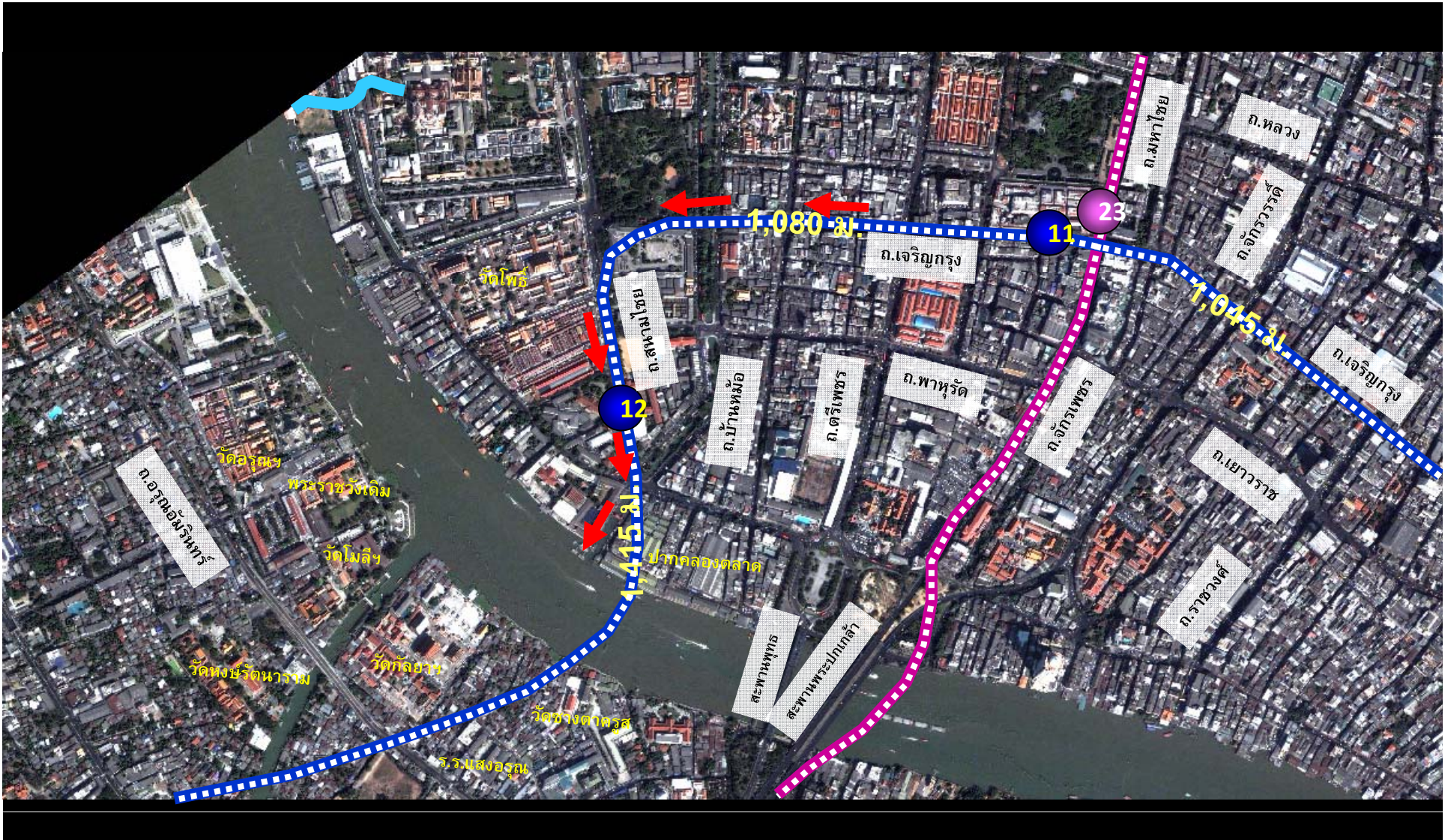




MRTA Extension

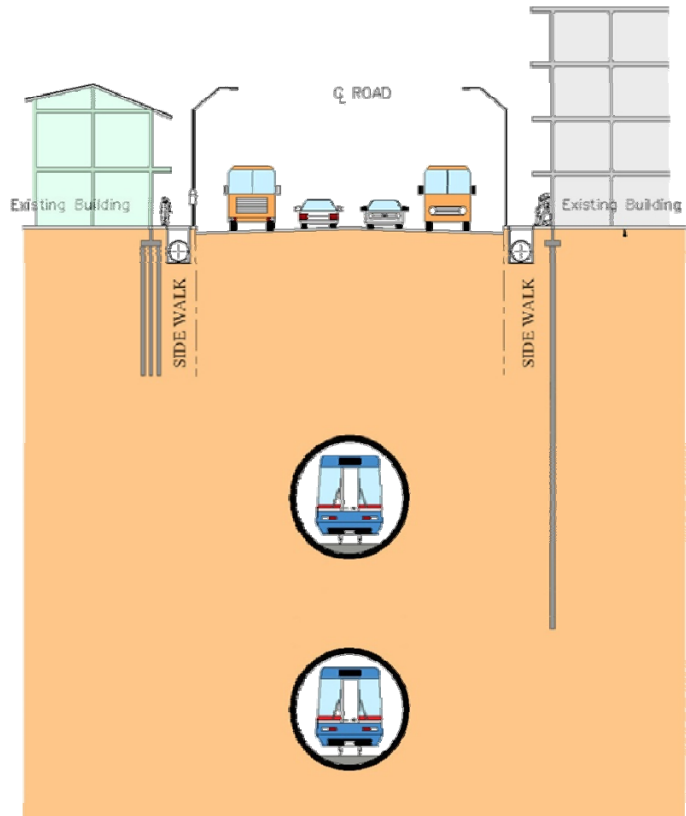
	MRTA (UNG.)	20	km
	BLUE LINE (UNG.)	5	km
	BLUE LINE (ELV.)	22	km
	STATION (UNG.)	4	sta.
	STATION (ELV.)	15	sta
	DEPOT	1	place
	PARK & RIDE	1	place



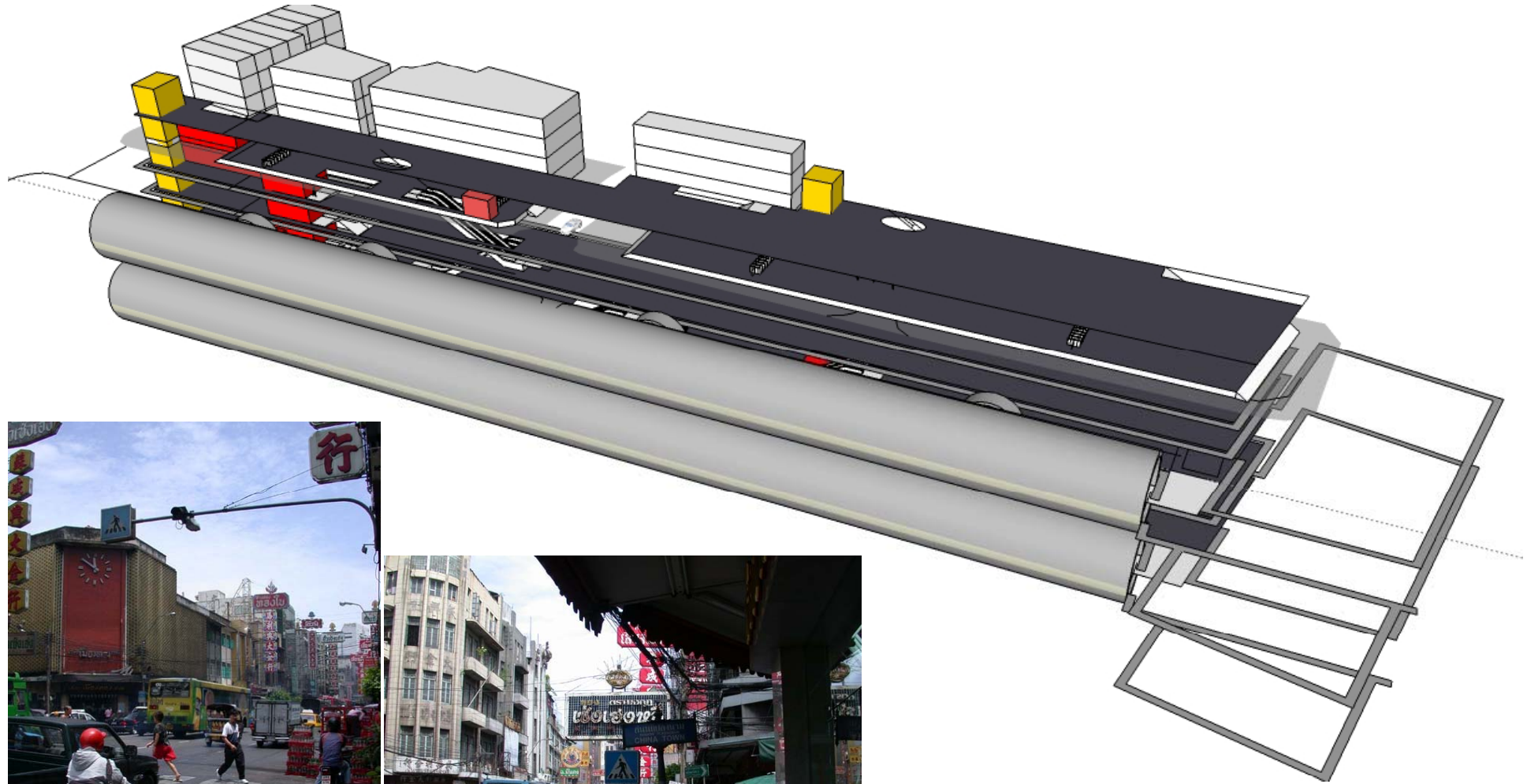


Critical Areas

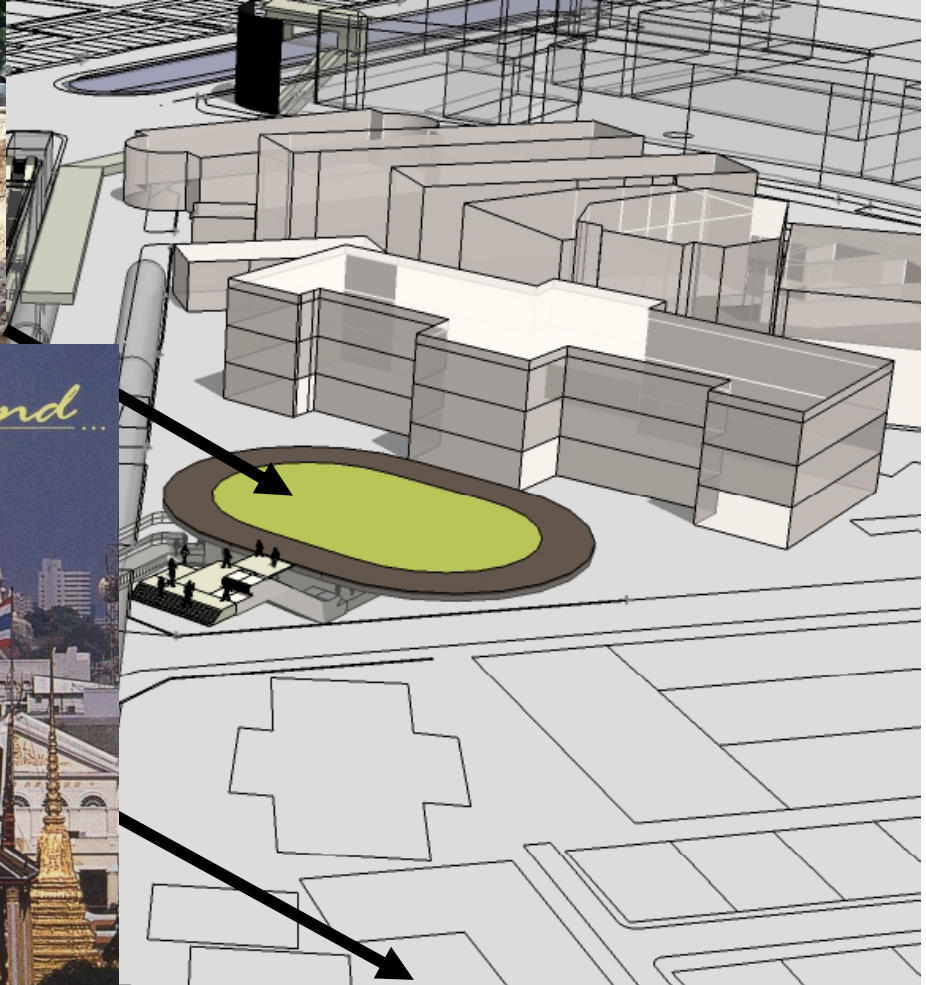




BS11 WANGBURAPHA STATION



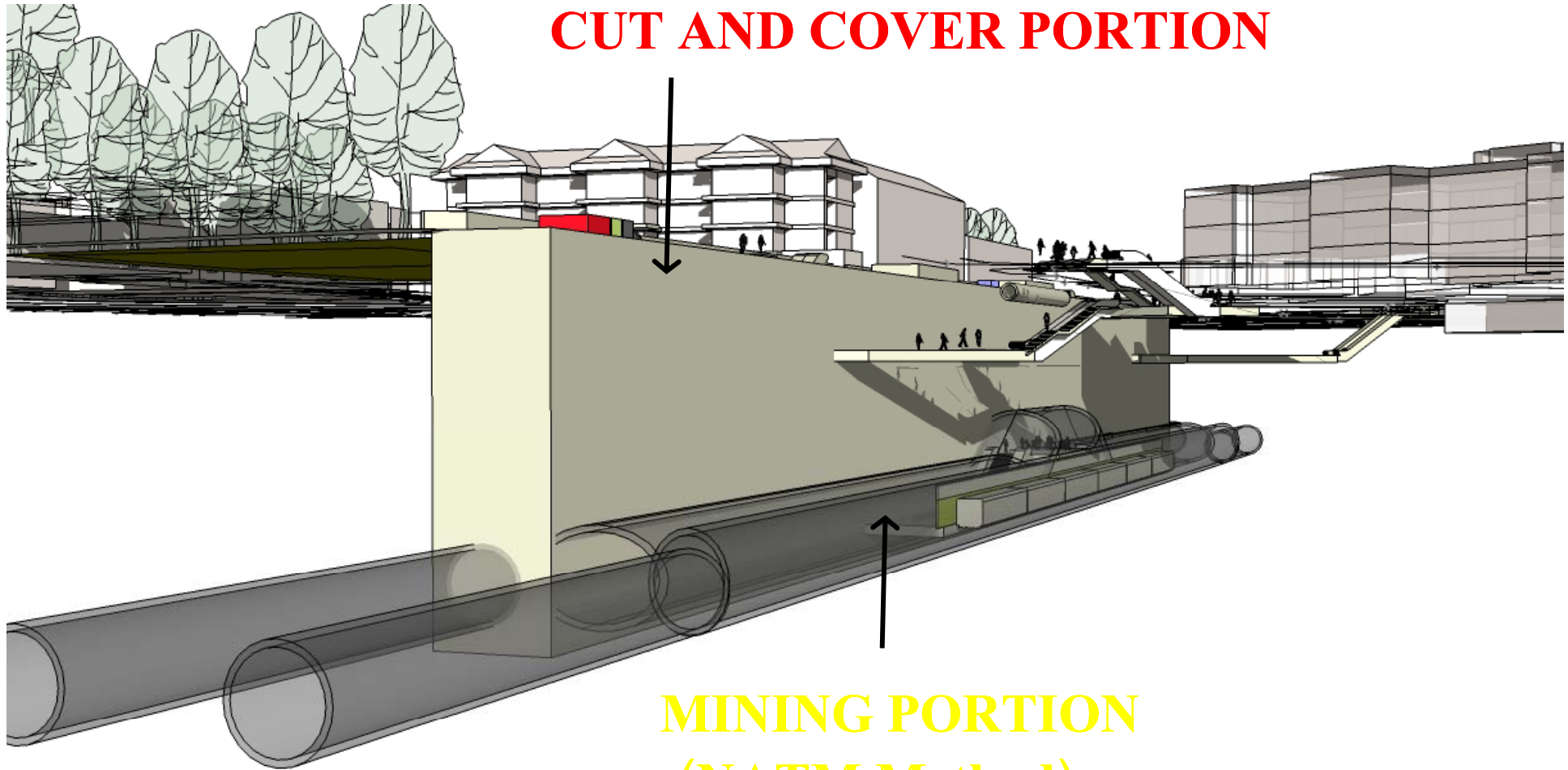
BS12 SANAMCHAI STATION



Imposed by Environmental and Old City Commisioners

BS12 SANAMCHAI STATION

CUT AND COVER PORTION



MINING PORTION (NATM Method)

PERSPECTIVE

Evidences:

Underground structures is safer than above ground structures.

Subway system in Bangkok is safe.