The project of reinforcement of embankment for measure against earthquake of the Murayama-Shimo Reservoir

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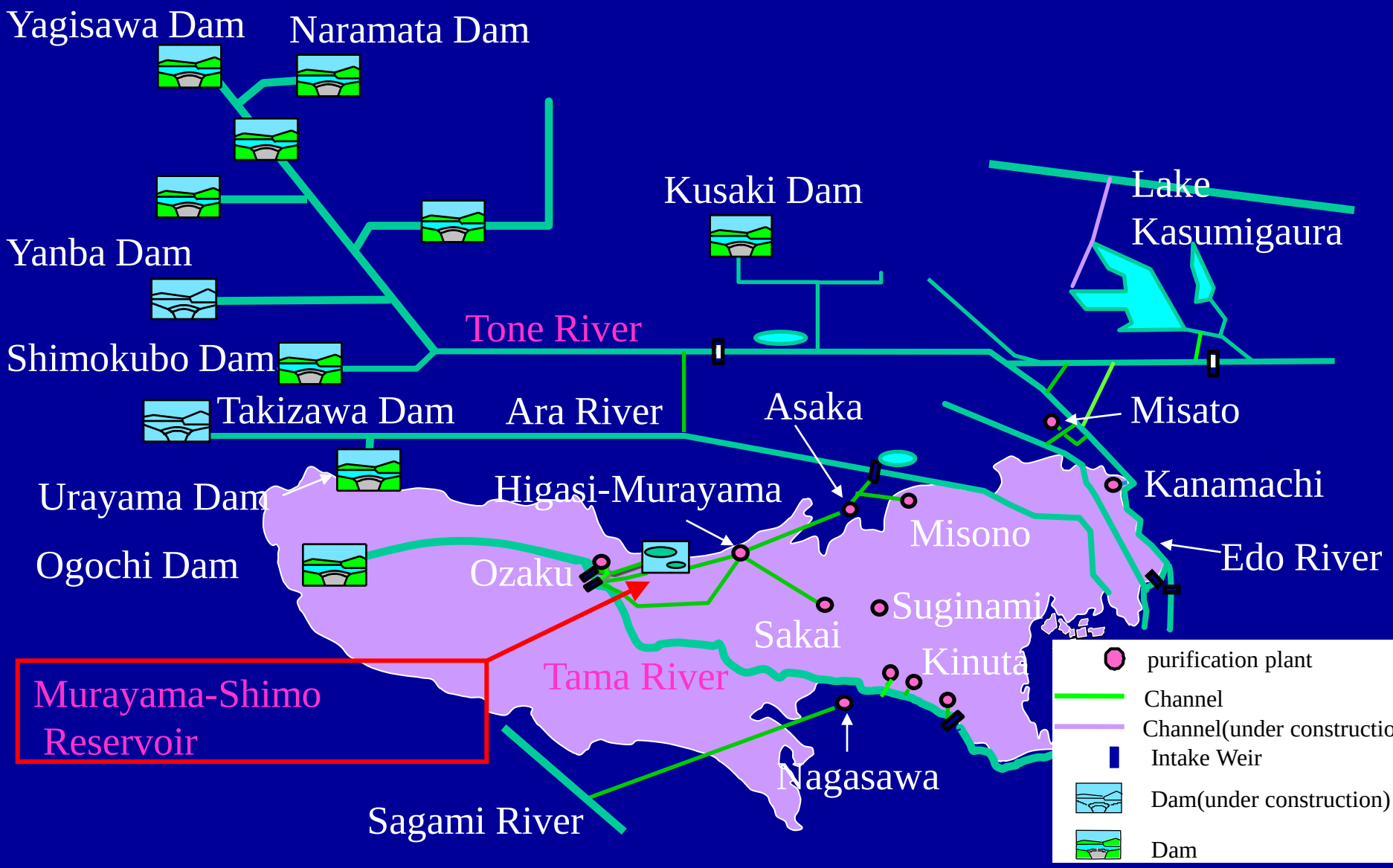
Outline of Tokyo Waterworks

TABLE I : Service area etc. 2008 FY

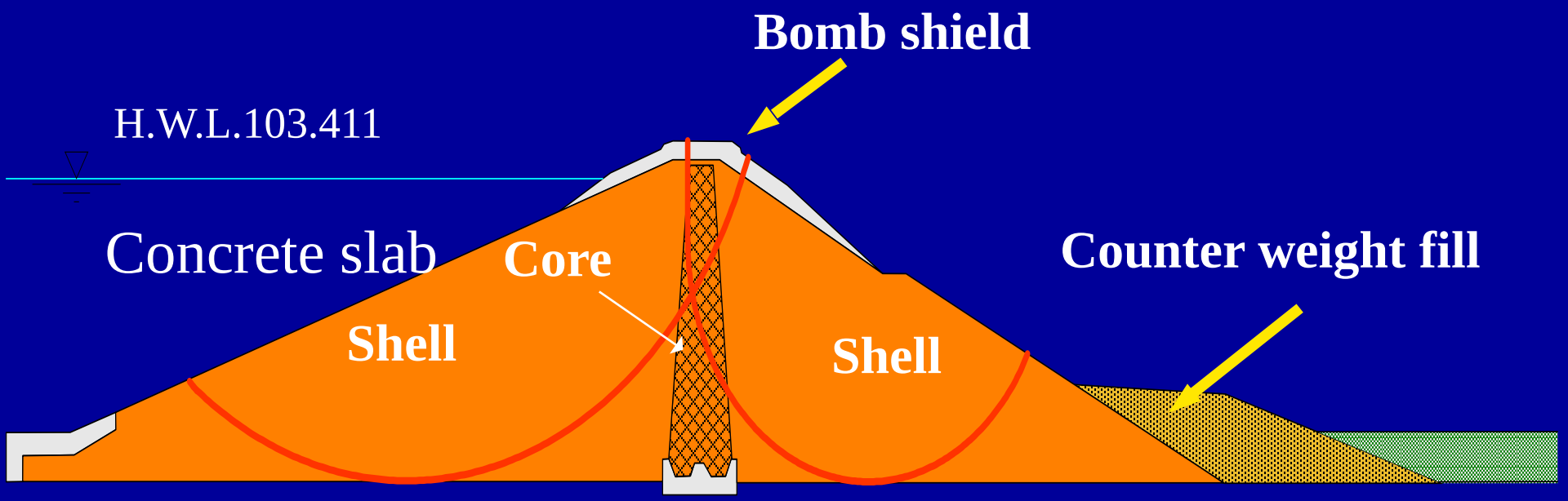
Service area	**1222.78km^2**
Population served	**12,554,106(people)**
Rate of service pervasion	**100%**
Number of service connections	**6,831,308(cases)**
Total length of distribution pipes	**25,823km**
Total production capacity	**6,859,500(m^3/day)**
Total annual water supply volume	**1,581,925(10^{3}m^3)**
Max. daily water supply volume	**4,824,000(m^3/day)**
Av. daily water supply volume	**4,334,000(m^3/day)**

Outline of Tokyo Waterworks



Murayama-Shimo Reservoir

Cross-section of Murayama-Shimo Reservoir

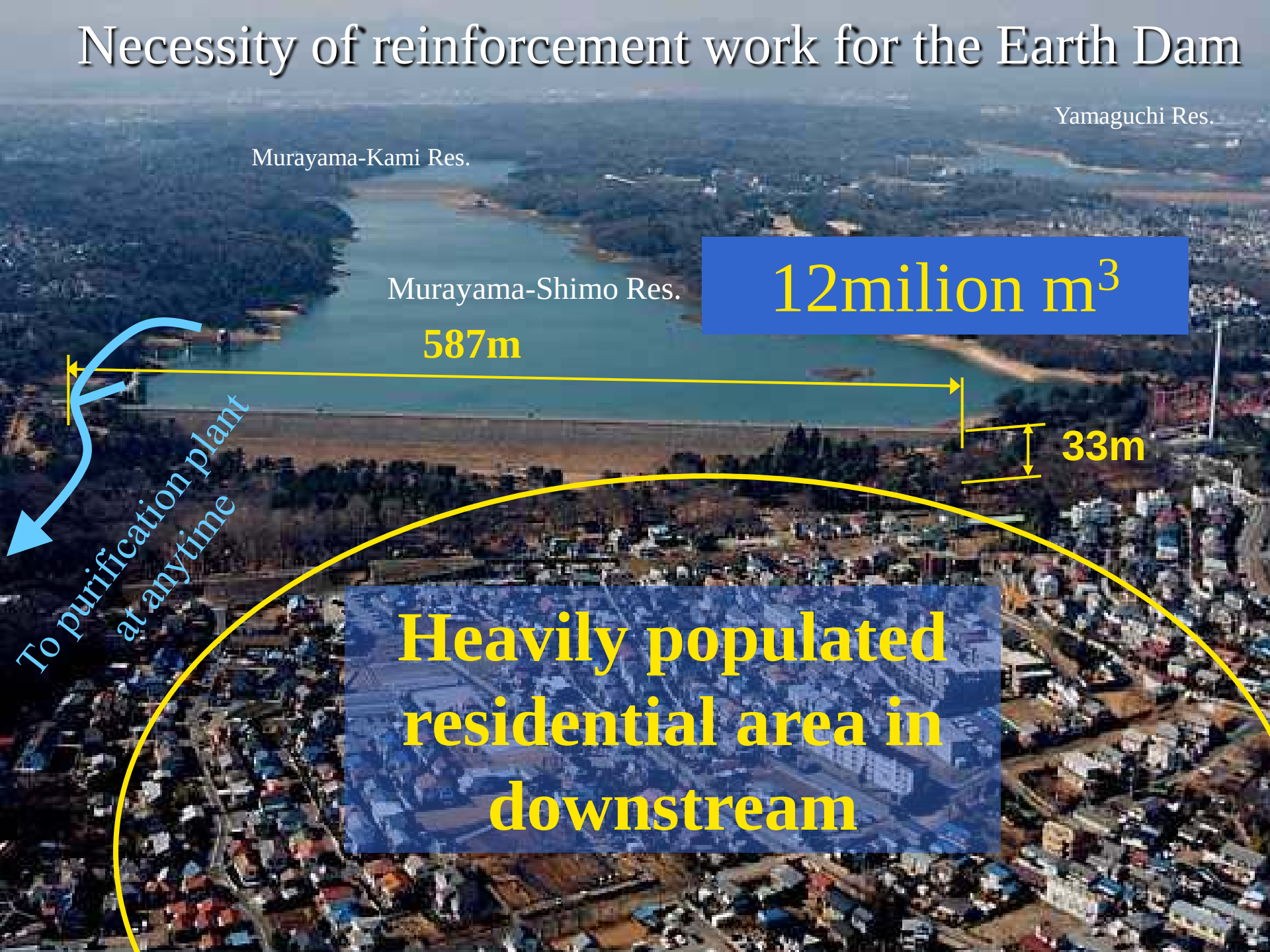


Murayama-Shimo Reservoir

Outline of Presentation

- Necessity of reinforcement
- Reinforcing method
- Placement of geogrid layers
- Procedure for reinforcing

Necessity of reinforcement work for the Earth Dam



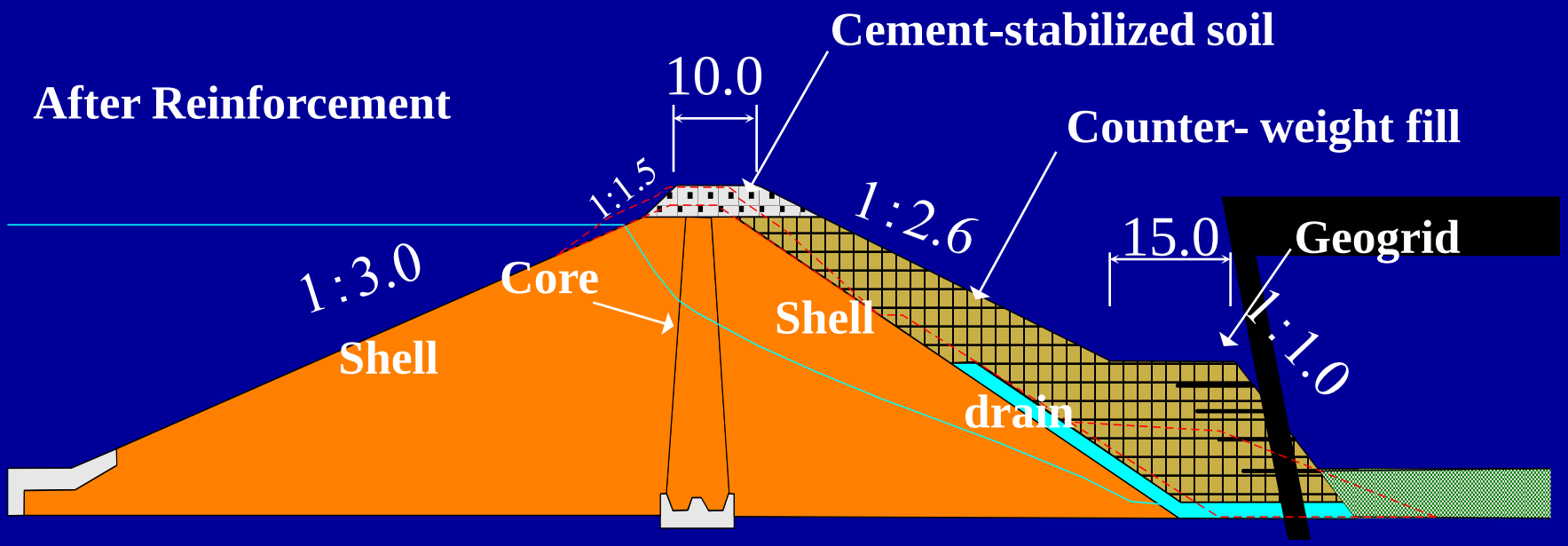
Assumption Earthquake

Assumption Earthquake	LV	Type	Magnitude	Acc Max (gal)
Ansei-Edo	LV1	Inland	6.9	186.3
Minami-Kanto	LV2	Trench	7.9	333.4
Tachikawa dislocation	LV2	Neighbor Inland	7.1	458.2

Safety ratio for slide by the circular sliding surface analysis of existing embankment

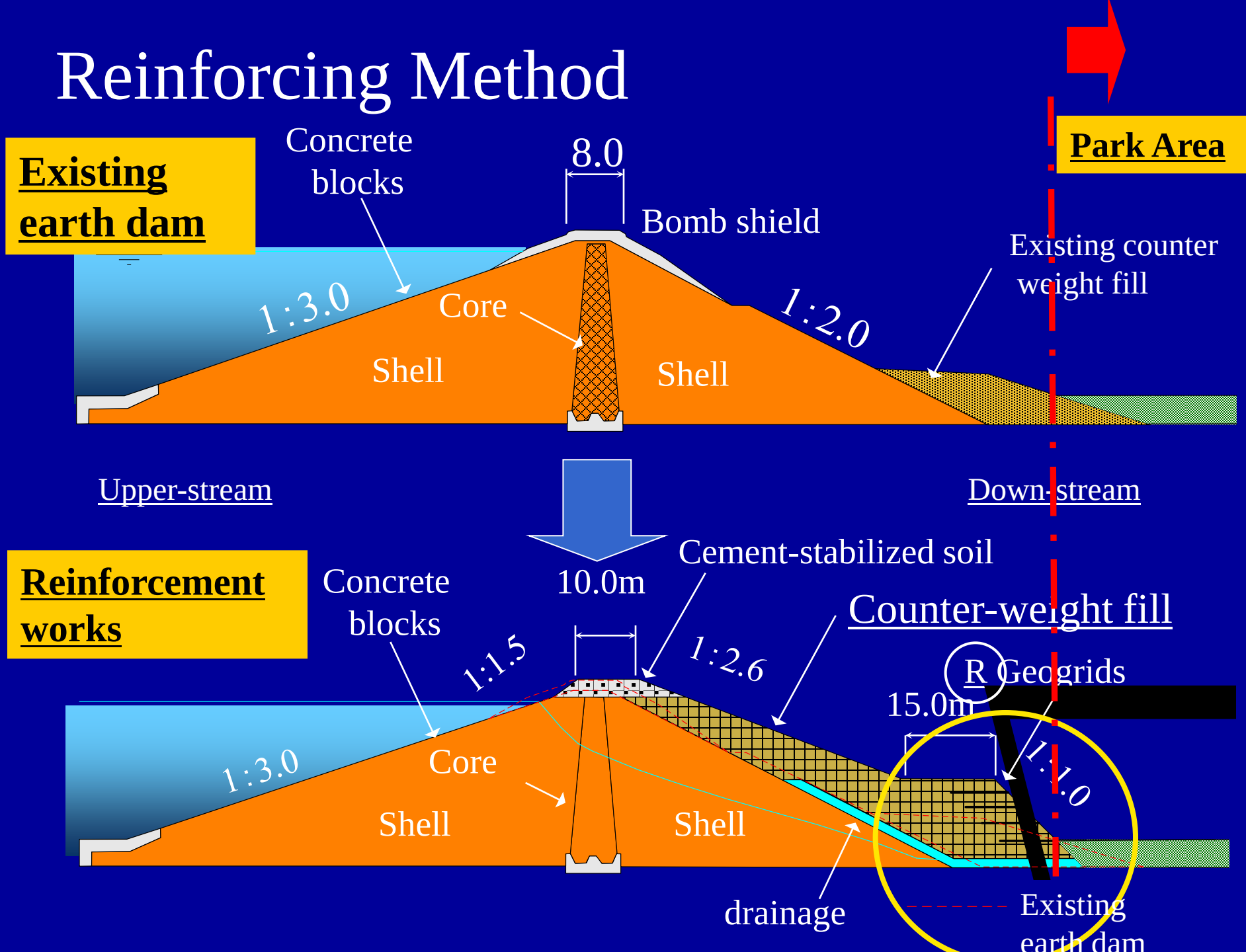
	upper-stream L.W.L.	down-stream H.W.L.	standard value
minimum safety ratio	1．153	0．814	1．2

Concept of reinforcing



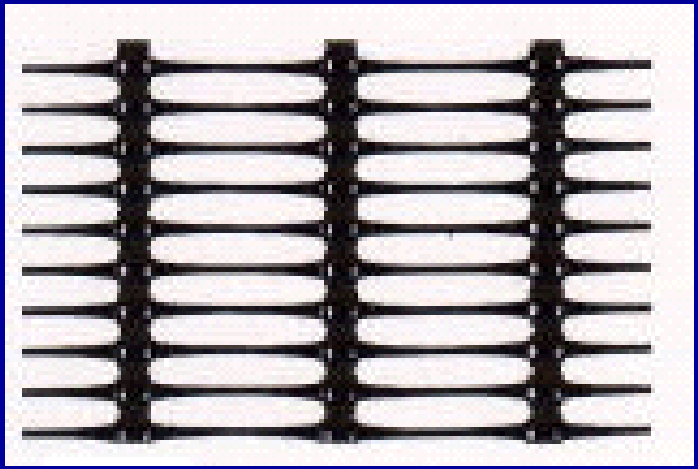
- Arrange inclined and level drainage layers on the downstream slope
- Construct a counter-weight fill above the drainage layers
- Reinforced the steep slope with polymer geogrid
- Cover the crest of the dam with a cement-stabilized soil layer

Reinforcing Method

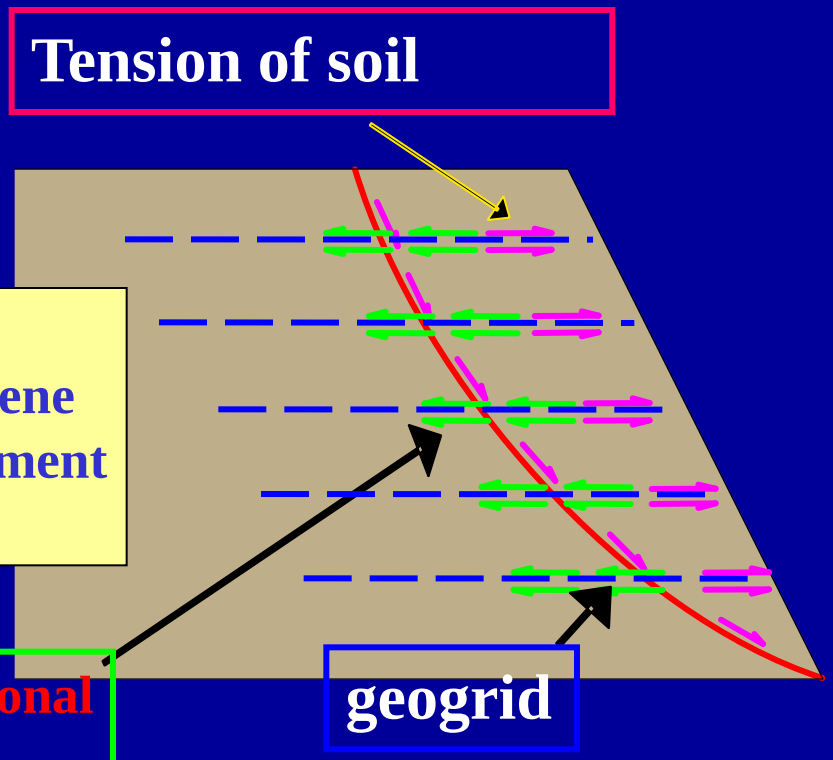


Geotextile (Geogrid)

geogrid



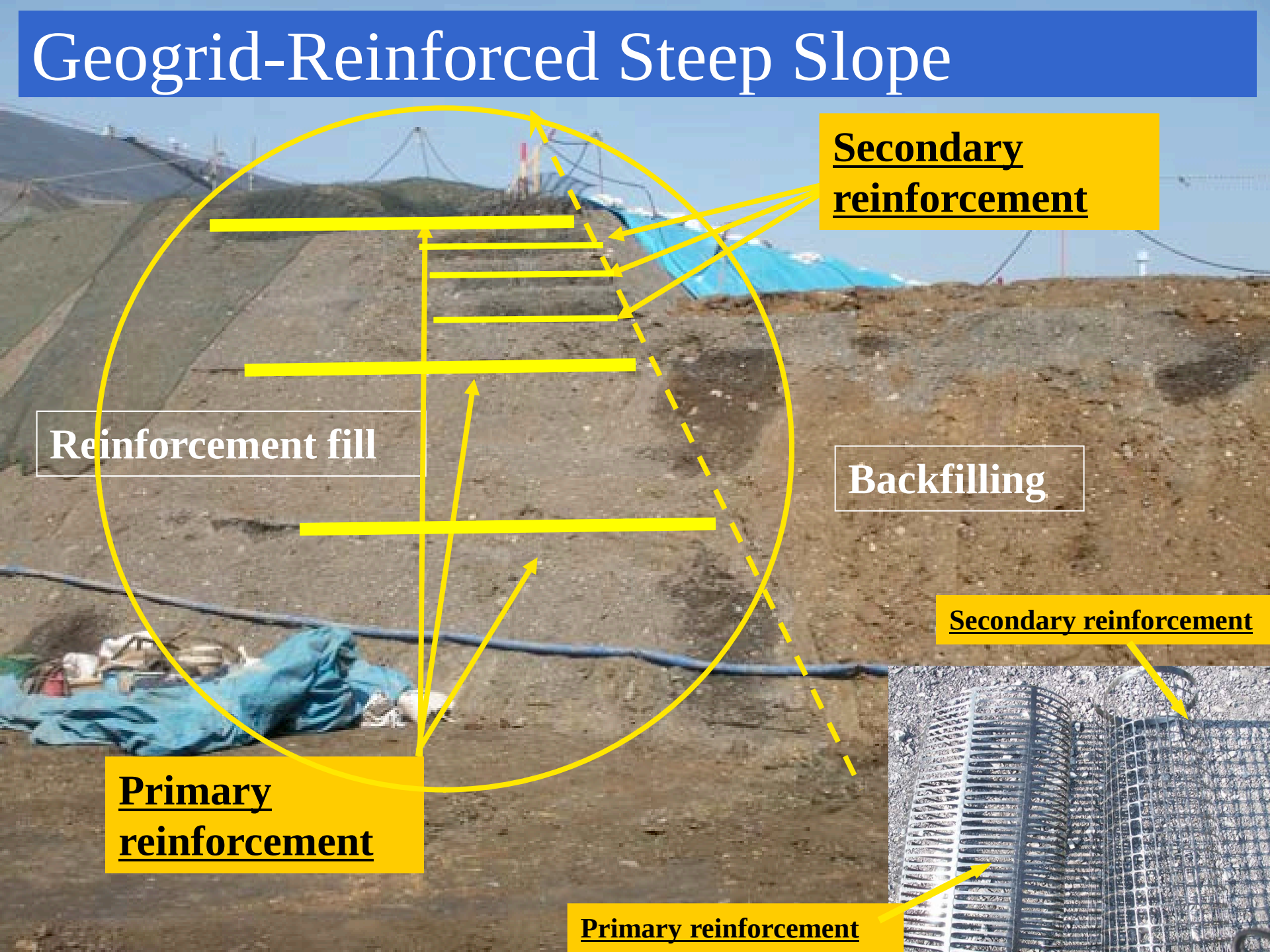
Effect of geogrid



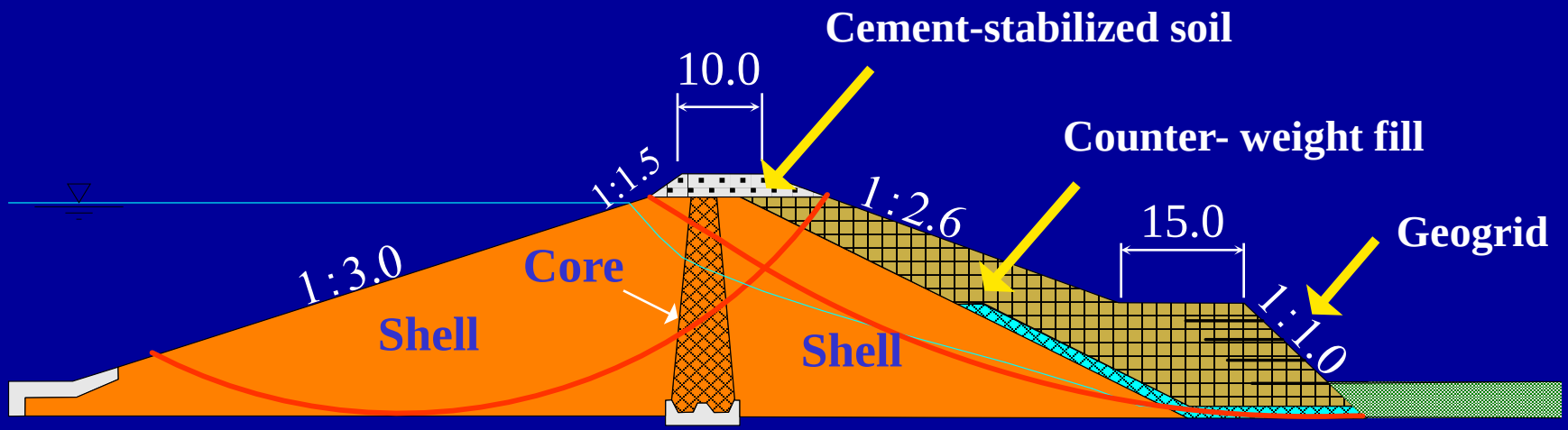
- **The reticular seat which made with high molecular matter such as polyethlene**
- **Resist pulling and used for reinforcement of fill with a sudden incline**

Resistance to tension by frictional force of a soil and geogrid

Geogrid-Reinforced Steep Slope



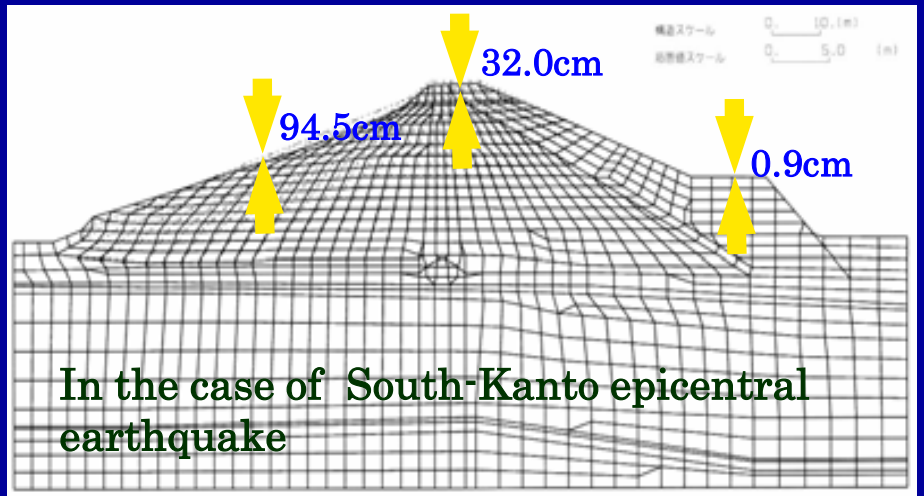
Safety ratio for slide by the circular sliding surface analysis of reinforced embankment



	upper-stream	down-stream	standard value
Minmum safety ratio	1. 239	1. 242	1. 2

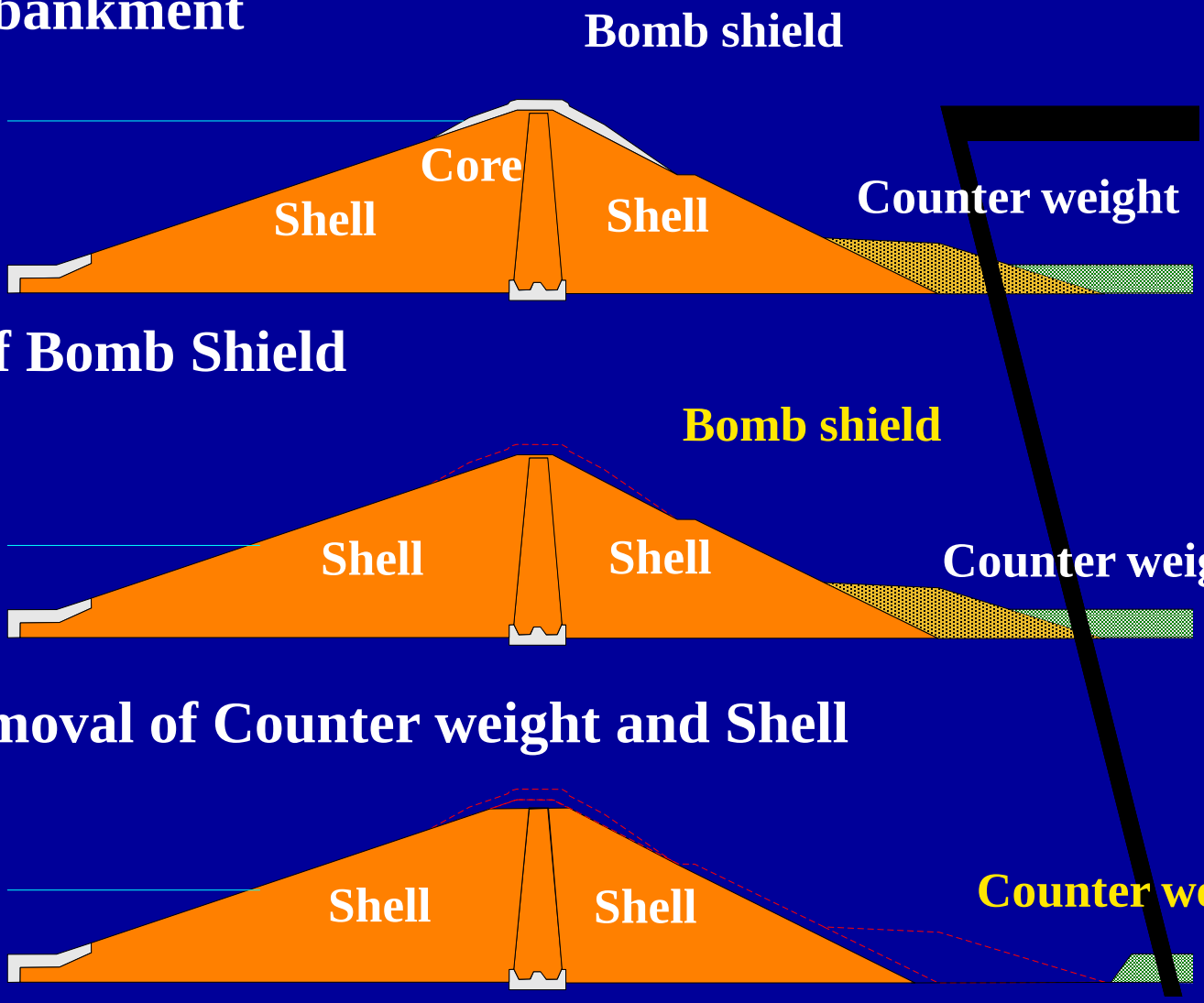
Prediction of the volume of residual deformation in the case of South-Kanto epicentral earthquake

Level of Earthquake motion	Assumption Earthquake	Magnitude	Minimum safety ratio	Deformation Volume of Crest
LV1	Ansei-Edo	M6.9	1.43	24.5cm
LV2	Minami-Kanto	M7.9	1.07	32.0cm
LV2	Tachikawa dislocation	M7.1	1.12	27.0cm



Procedure for reinforcing

Existing Embankment

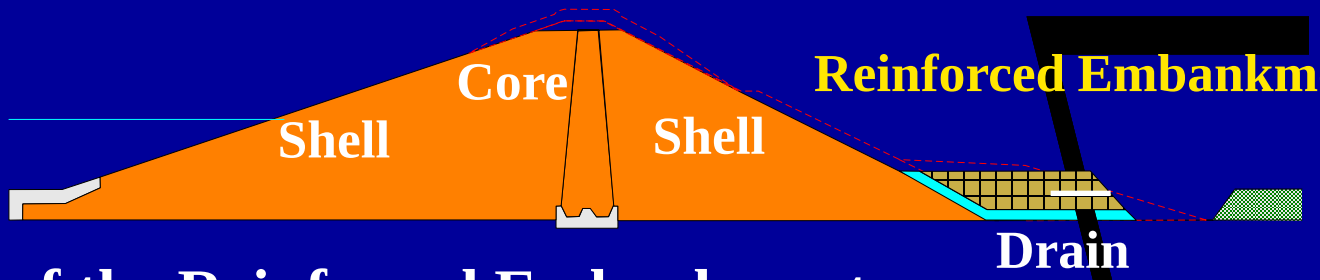


1.**Removal of Bomb Shield**

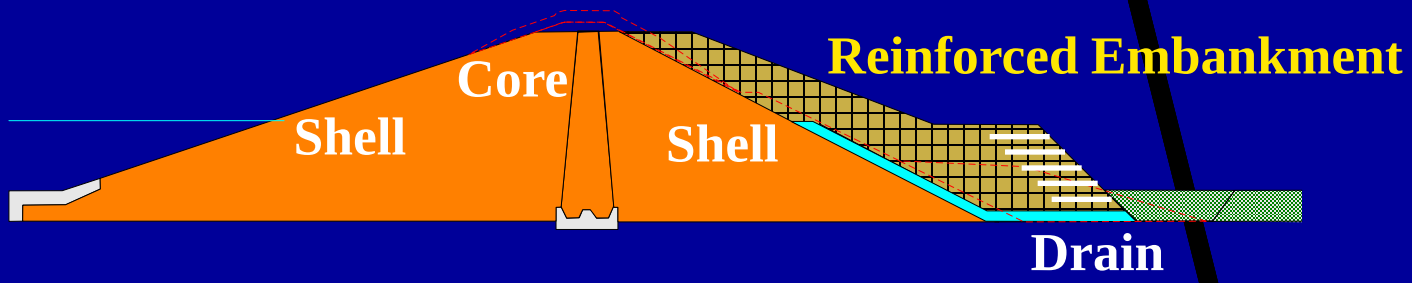
2.**Partial Removal of Counter weight and Shell**

Procedure for reinforcing

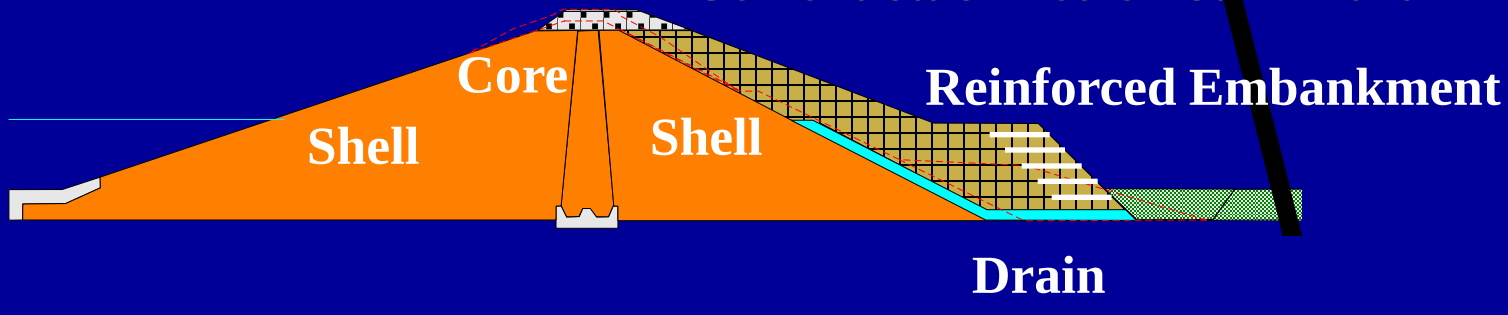
3.**Begin Embankment Construction**



4. **Completion of the Reinforced Embankment**



5.**Cement-Stabilized Embankment**



Removal of Bomb Shield

Removal of Bomb Shield

Partial Removal of Counter weight and Shell

Begin Embankment Construction

Placement of geogrid-layers

Geogrid Reinforced Steep Slope

Cement-Stabilized Embankment

Issues

- To confirm whether the tensile strains of the geogrid-reinforced slope is kept far below the tensile rupture strain, equal to about 10 %, it will be observed for a long period after the completion of this embankment.

- The deformation of the slope will also be monitored for some long period.

  This monitoring is necessary also to confirm that the stability design of this embankment is reasonably on the safe side.

CONCLUSIONS

- To ensure a sufficiently high seismic stability of an existing earth dam for a very important reservoir for water supply to Tokyo with a densely-populated residential area in front, on the downstream slope of the dam, a counter-weight fill with a17 m-high steep slope reinforced with HDPE geogrid layers was constructed.
- A 1:1 steep slope was adopted to alleviate a space restraint while to ensure a high seismic stability. The total area of the geogrid layers was 28,500 m2.
- As this project is the first case of reinforcing an existing earth dam by means of geogrid-reinforcement, the grading characteristics of the backfill was strictly controlled while a high degree of compaction was ensured.
- The long-term post-construction behavior of the geogrid-reinforced steep slope will be monitored while ensuring a long-term durability of the geogrid in the steep slope.

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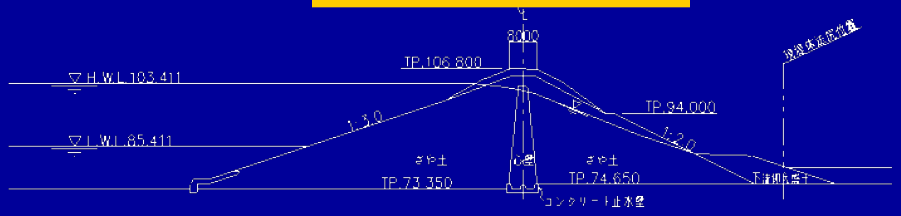
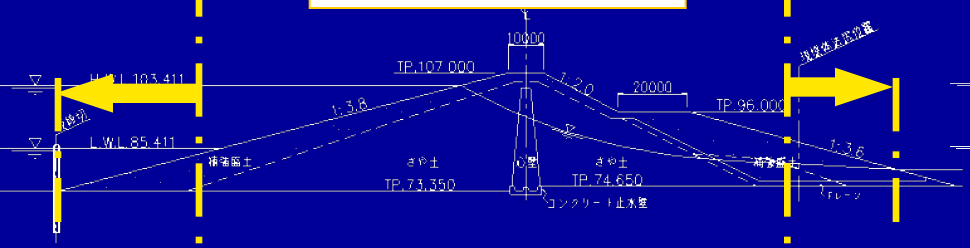
SURPORT

Reinforcing Method

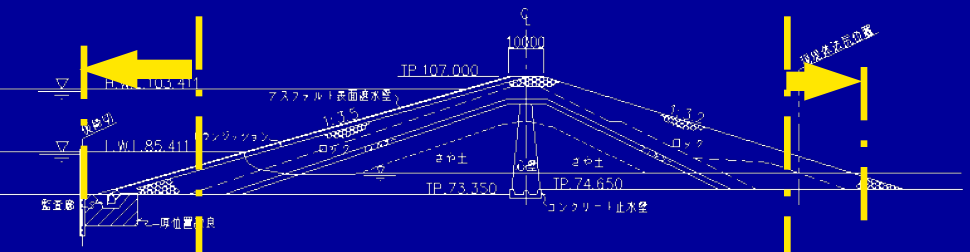
Existing earth dam



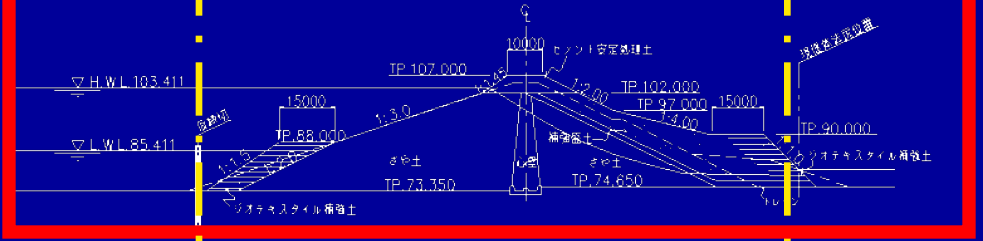
Earth fill dam



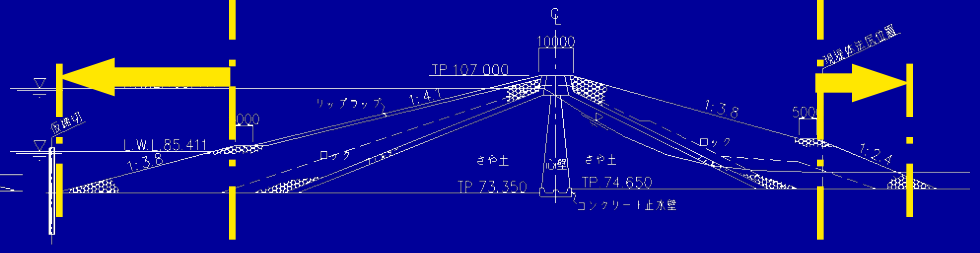
Rock fill dam



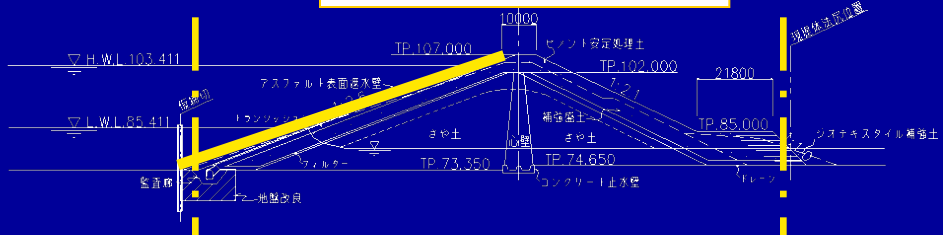
Reinforced earth fill dam



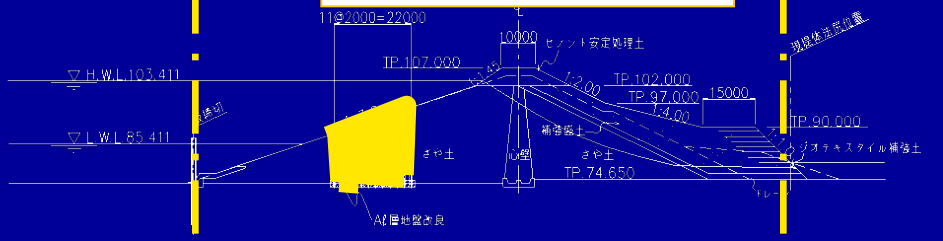
CFRD



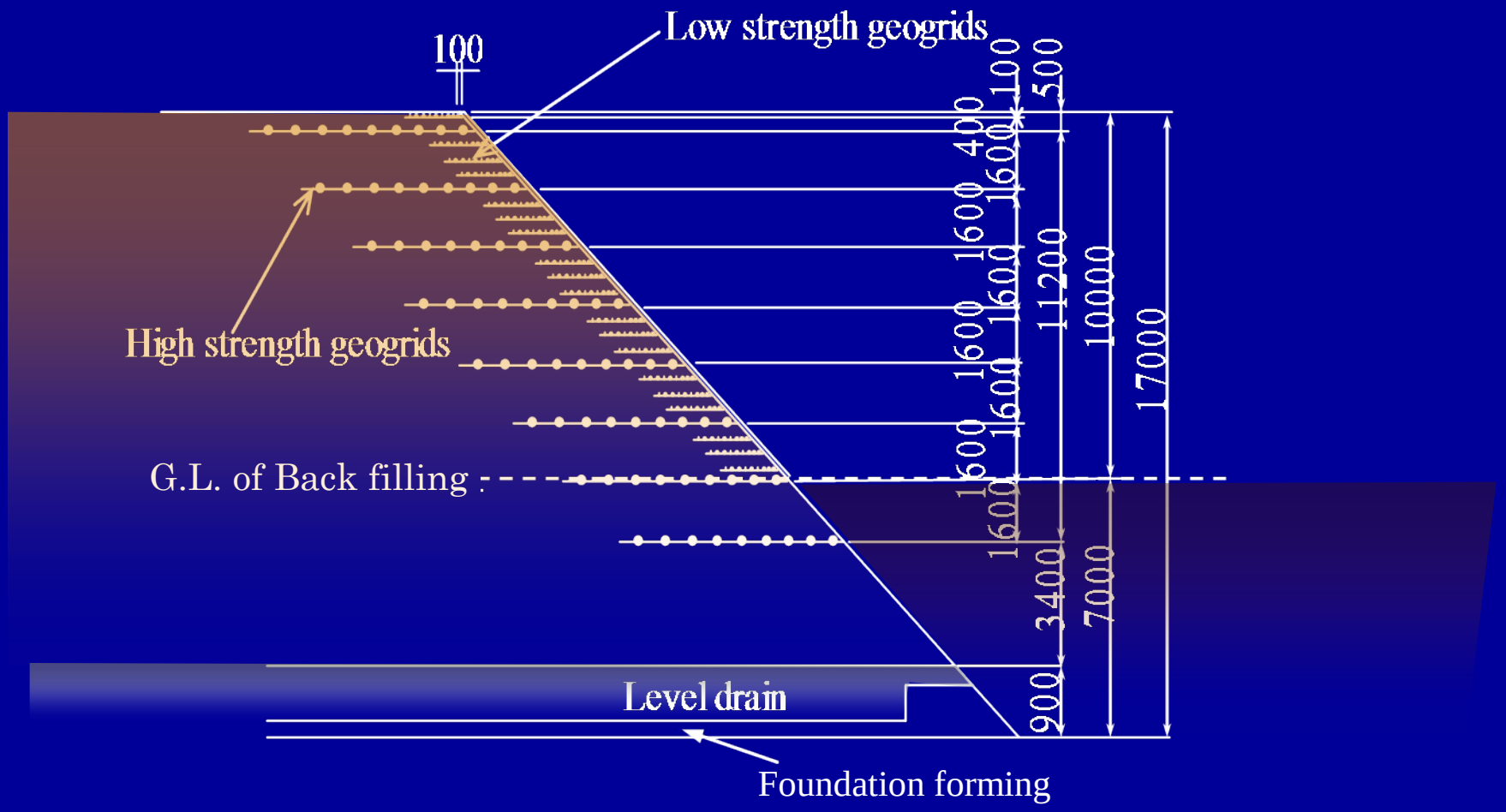
As. facing & Reinforced earth fill dam



Chemical grouting & Reinforced earth fill dam



Placement of Geogrid Layers



Primary Reinforcement

Secondary Reinforcement