What can one do with concrete?

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LBNE Collaboration meeting

July 2009

Vessel/liner sub-group meeting

How does BNL plan to participate in the liner vessel group?

- Interested in the concrete against rock and free standing cement vessel options for vessel construction.

Different designs to be investigated

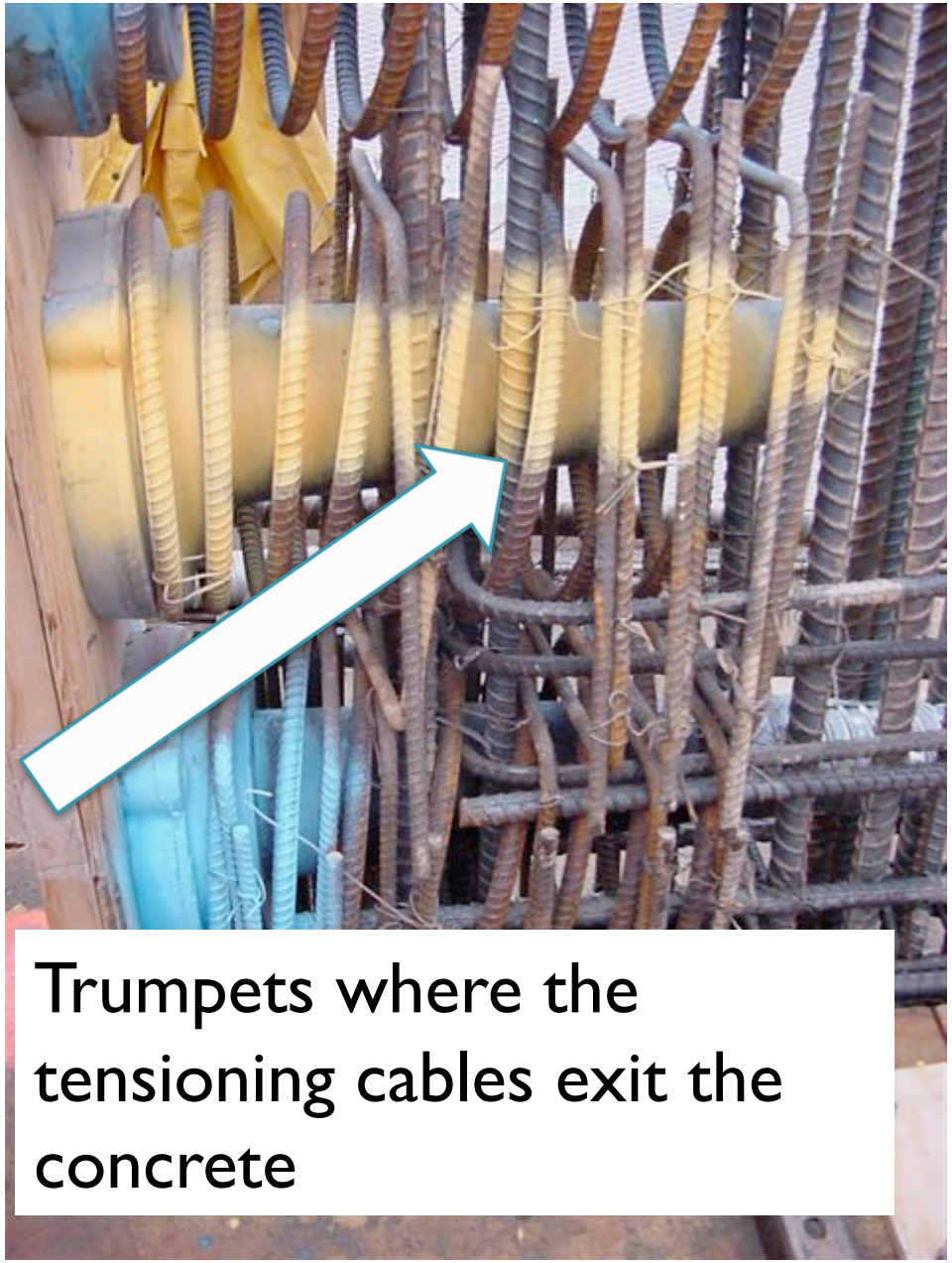
	Unit	1 Steel self supporting	2 Concrete blocks	3 Unitary post-stressed concrete vessel self supporting	4 Liner on shotcrete	5 Cast concrete against rock	6 Pressure balanced wall
Fiducail Radius	m	25	25	25	25	25	25
Buffer between fiducial radius and PMT	m	1	1	1	1	1	1
PMT module thickness	m	0.5	0.5	0.5	1	1	1
Gap between PMT module and tank wall	m	0	0	0	0.2	0	0.2
Sealing/coating layer thickness	m	0.005	0.005	0.005	0.005	0.005	0.01
Tank water radius	m	26.51	26.51	26.51	27.21	27.01	27.21
Tank wall thickness top	m	0.05	0.5	1	0.1	1	0.01
Tank wall thickness bottom	m	0.12	0.5	1.0	0.1	1	0.0
Tank wall thickness average	m	0.09	0.50	1.00	0.10	1.00	0.01
Tank outer radius	m	26.63	27.01	27.51	27.31	28.01	27.22
Access/drainage/balance gap	m	2	0.2	3	0	0	0.5
Rock wall raidus	m	28.63	27.21	30.51	27.31	28.01	27.72
Tank wall mass	tonne	5989	11453	23331	2316	23755	231
Fiducial volume	cu m	100000	100000	100000	100000	100000	100000
Fiducial height	m	51	51	51	51	51	51
Tank water height	m	54	54	54	54	54	54
Tank floor thickness	m	2	2	2	2	2	2
Excavation height	m	56	56	56	56	56	56
Excavation volume (without upper part)	cu m	144155	130207	163712	131166	137978	135184
Normalized		1.04	0.94	1.19	0.95	1.00	1.00

Post-Stressed Concrete Vessel

- Typically a free standing water tight container.
- Slipform construction on ID and OD.
- Conduits are embedded into the concrete.
- After the concrete is poured cables are post-tensioned at buttress locations on the OD.
- The post-tensioning keeps the concrtet always in compression which is what concrete likes.

Ductwork for post tensioning

Photo from T.E. Ibberson:
clinker silo at Unionbridge, Maryland,
Lehigh Cement Plant.



Trumpets where the tensioning cables exit the concrete

Advantages and disadvantages

- The vessel is a monolithic structure without water seals except at the base.
- The vessel is free standing so there are no influences from external hydrostatic pressure or geological failures.
- Need 6-10' outside the vessel of free space required where the tensioning is to be done.
  - 5' are required elsewhere.
  - Larger cavern is necessary.
- Penetrations are possible in the concrete.
  - Possibly shorter cables.
- Access to the outside of the vessel would allow repairs w/o emptying the container.
  - Maintenance is easier.

General information

- 36” wall would requires 65 cubic yards of material per foot of silo.
- 6-9” per hour slip rate.
  - Similar project had 6” planned and achieved 9”
  - 4.37 - 6.56 hours per meter.
  - @5hours/meter 58m total height.
  - 290hr or 12 days to slip the whole structure.
- Material availability is an issue.
  - Underground storage?
  - Rock availability?
  - Use mine water?

Single surface slip form

- No post-tensioning is done.
- Cracks due to shrinkage must be sealed with epoxy.
- The rock wall is used as one surface.
  - Any non-uniformity in the wall increases the cost as it must be filled with concrete.
- No access to the outside surface of the vessel.

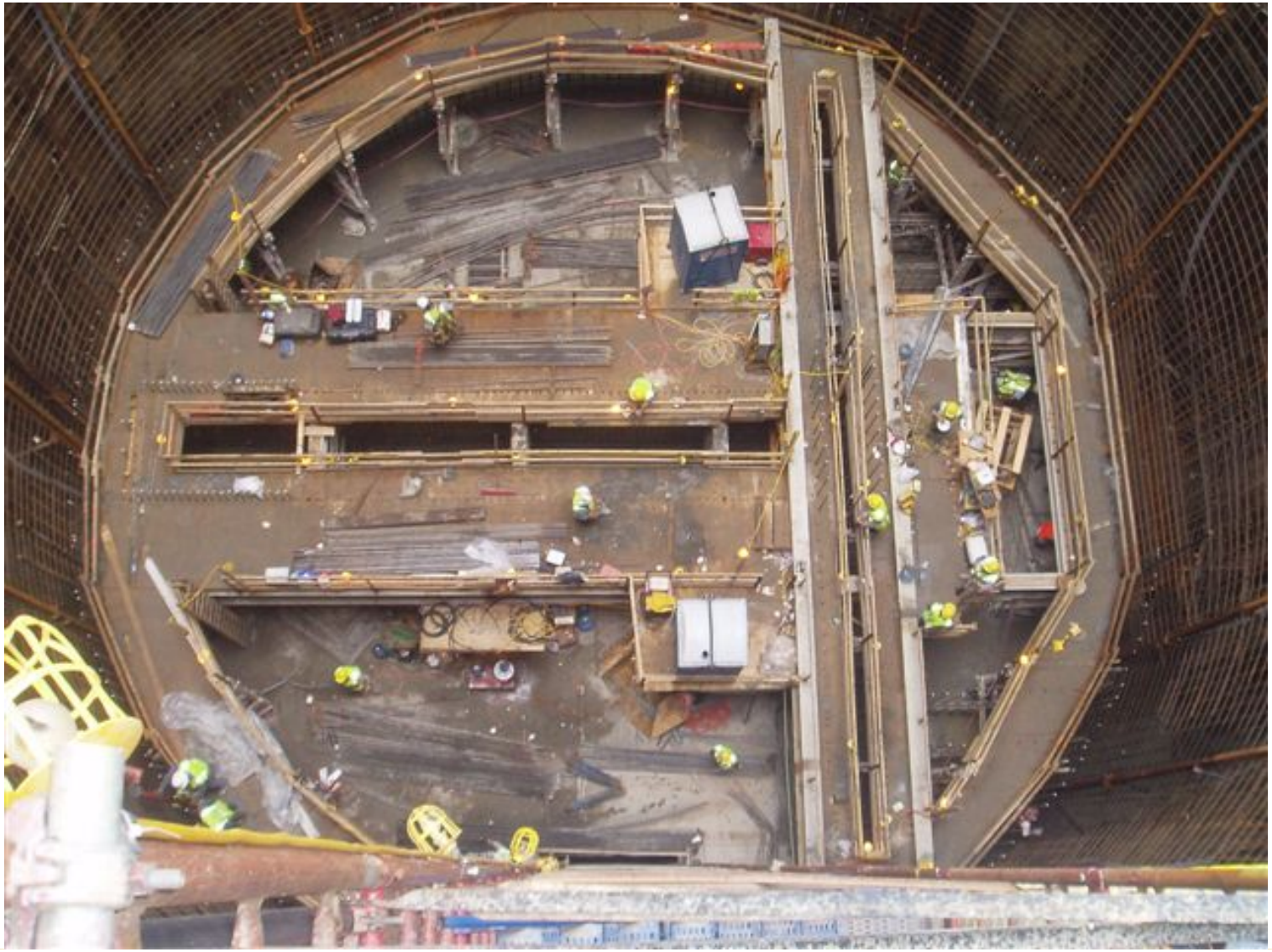
Projects by TE Ibberson:
70’ dia 160’ deep waste water pumping facility in Atlanta Georgia.

Single sided slipform wall

Preformed port in structural vessel wall

Workers on Slipform platform

Slipform platform on shaft ID shown from above.



Imbedded steel plates for mounting are possible

Imbedded plate top view

Are hybrids possible?

- Do not know if one can combine the technologies.
  - Single side slip form most the radius
  - Double side slip form the area where the tensioning trumpets are positioned.

Plans

- Plan to purchase 1 year of contract engineering effort with civil/mining expertise to assist in design development.
- Plan to contract consulting services to develop the slipform based designes.
- Will hire a new mechanical engineer to work part time in the liner subgroup.

Backup