Estimation of Prestress Losses

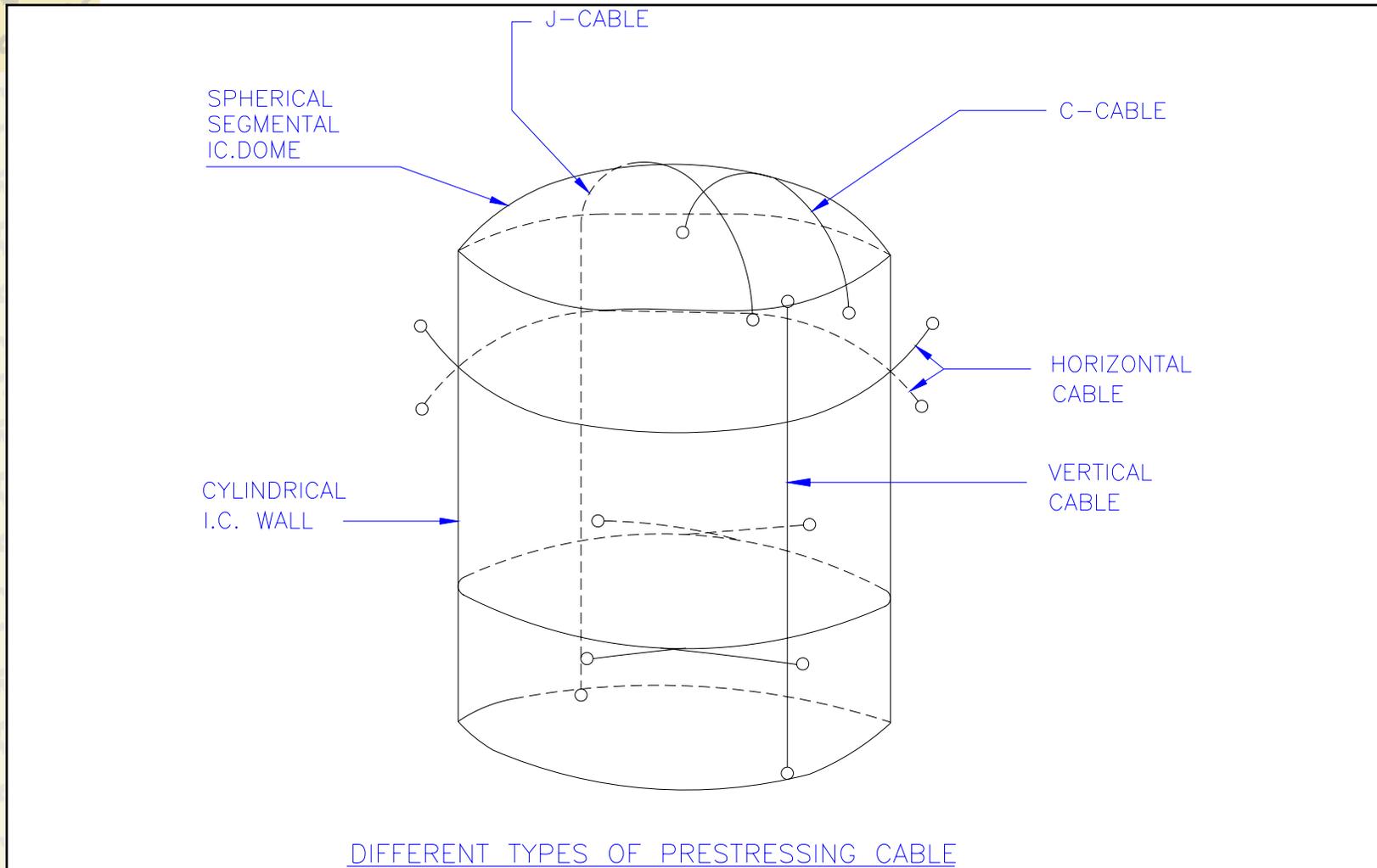U. S. P. Verma, Executive Director (Civil & Engg. Services)

Raghupati Roy, Additional Chief Engineer (Civil)
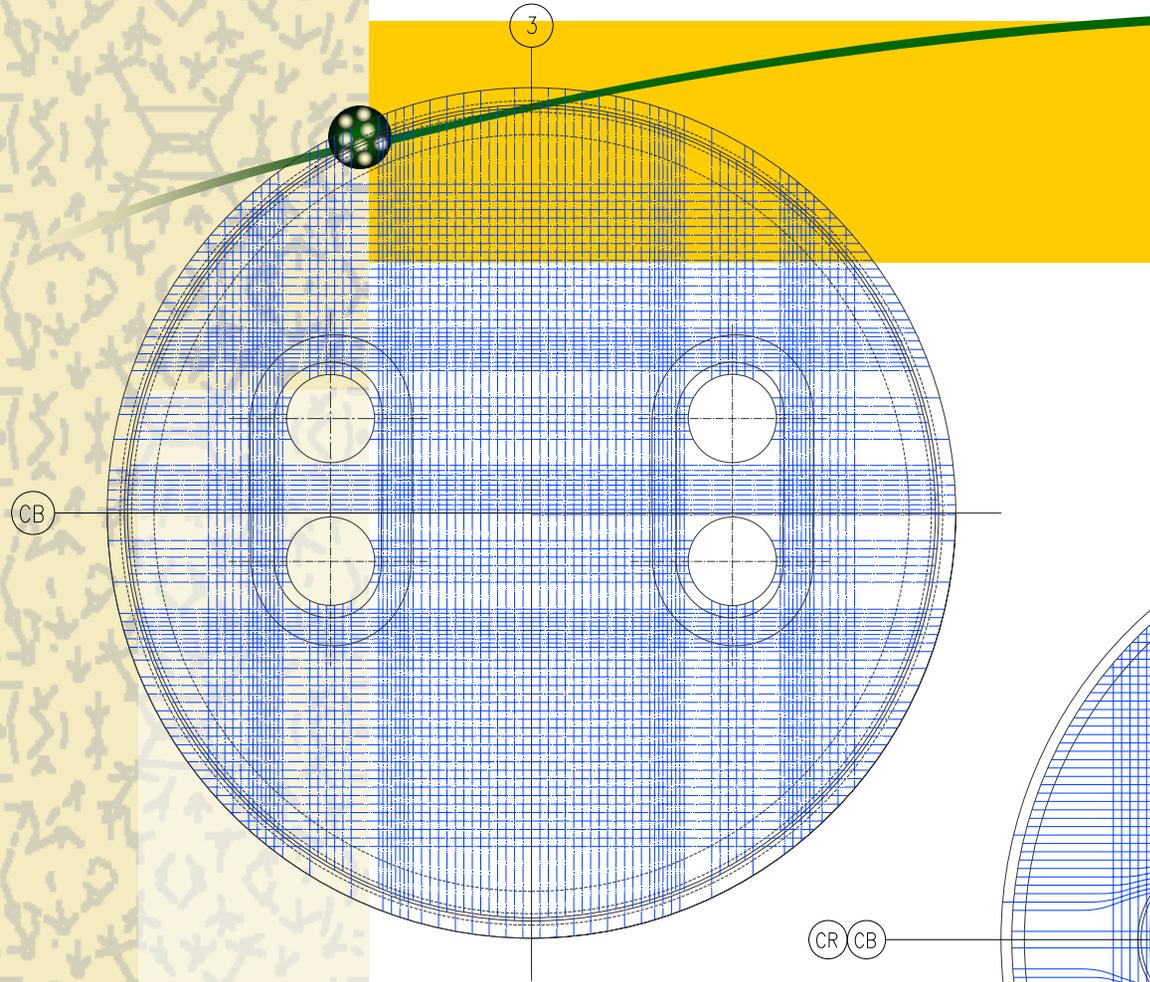
Indrajit Ray, Deputy Chief Engineer (Civil)

Nuclear Power Corporation of India Limited, Mumbai

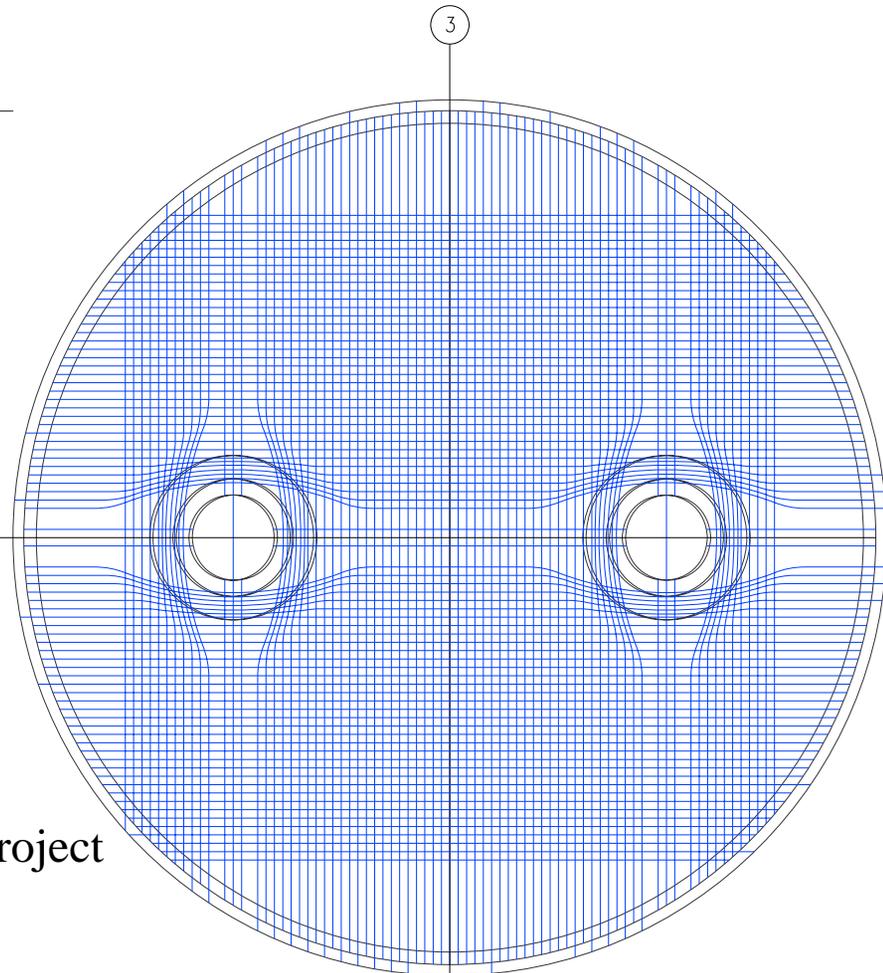DIFFERENT TYPES OF PRESTRESSING CABLE

Labels in figure: J-CABLE, C-CABLE, SPHERICAL SEGMENTAL IC.DOME, HORIZONTAL CABLE, VERTICAL CABLE, CYLINDRICAL I.C. WALL

UPPER CABLE

LOWER CABLE

PS Cable Layout of 220MWe Projects
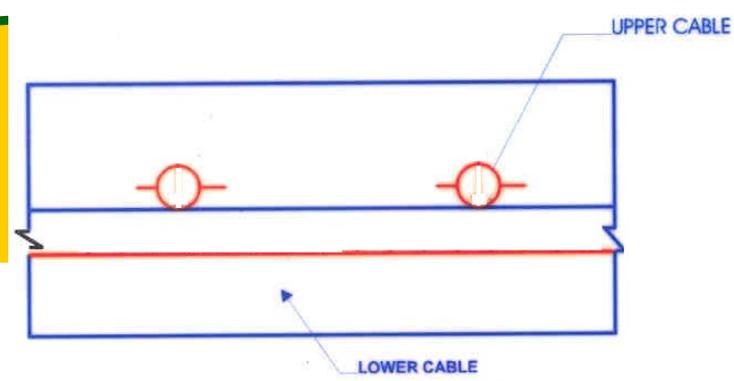
PS Cable Layout of 540MWe/700Mwe Project

LAYOUT OF VERTICAL PRESTRESSING CABLES ON DEVELOPED VIEW OF I.C WALL AT RADIUS. R=25175 (BETWEEN AXES CBS-W-CBN)
(FROM INSIDE REACTOR BUILDING : LOOKING FROM EAST TOWARDS WEST)
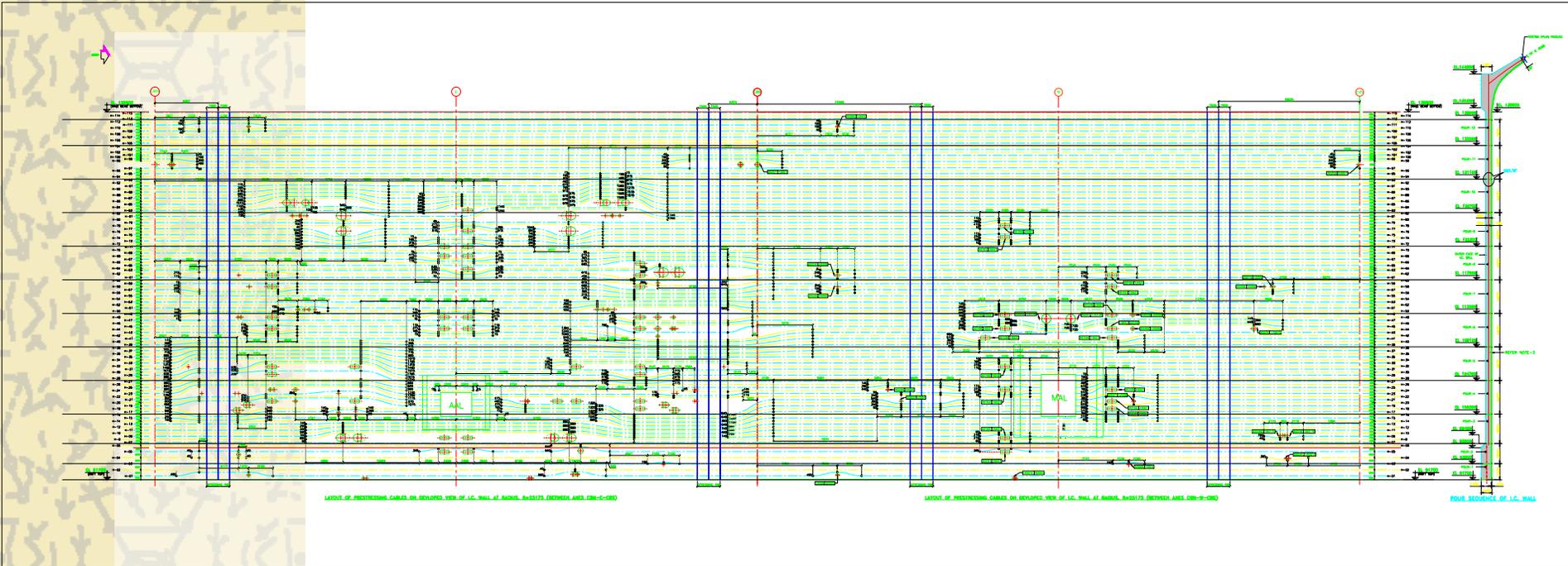
LAYOUT OF VERTICAL PRESTRESSING CABLES ON DEVELOPED VIEW OF I.C. WALL AT RADIUS, R=25175 BETWEEN AXES C8N=E=C9S
(FROM INSIDE REACTOR BUILDING : LOOKING FROM WEST TOWARDS EAST)
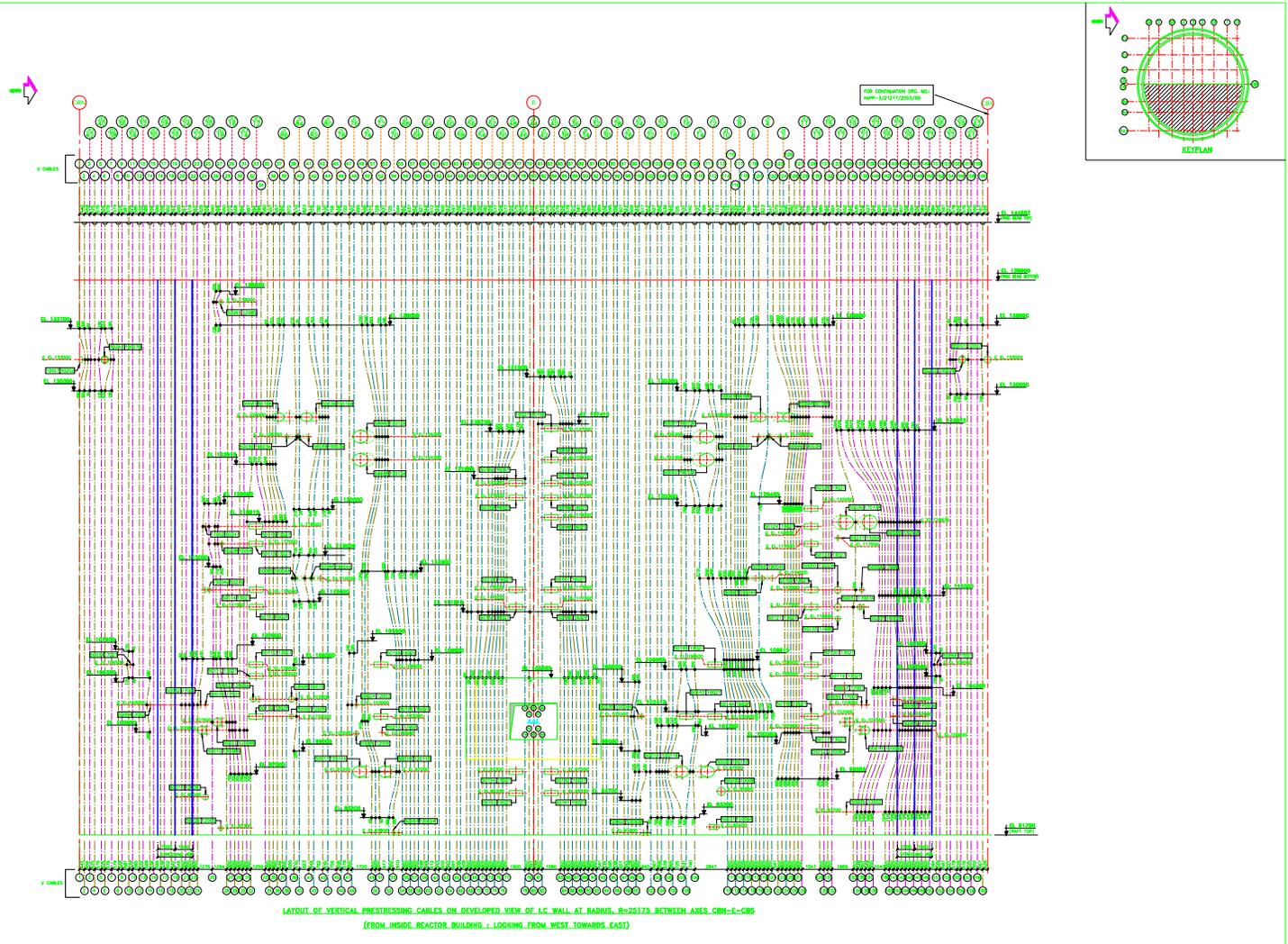
Short Term Losses

☀ Initial (Short Term) Losses due to

- – <u>Wobble & Friction</u> Loss
  - During Stressing
- – Anchorage-draw-in (Slip Loss)
  - Due to Locking of Cables at Anchorage End
- – Elastic Shortening
  - Due to stage wise Prestressing of Cables
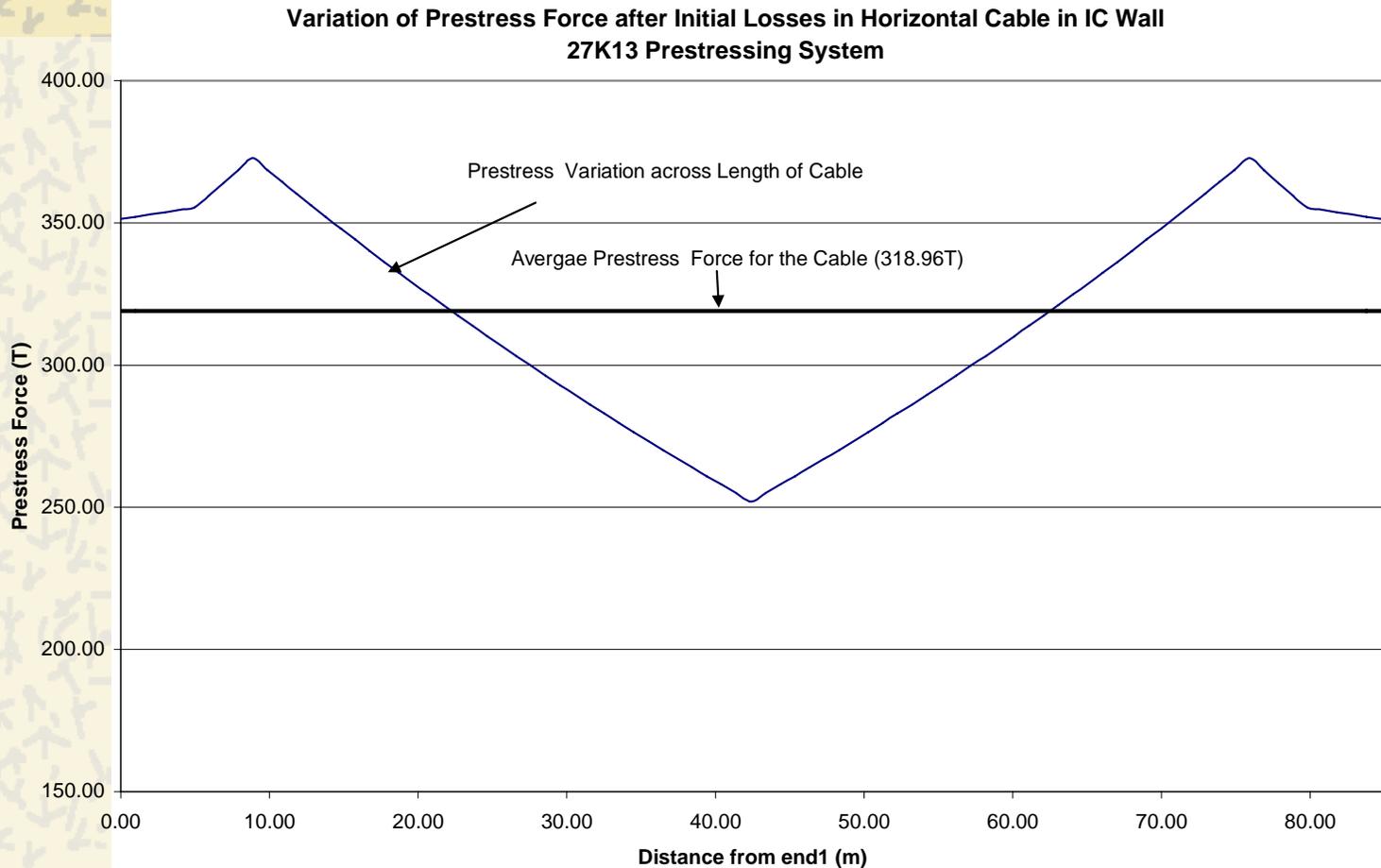
Variation of Prestress Force after Initial Losses in Horizontal Cable in IC Wall
27K13 Prestressing System

Prestress Variation across Length of Cable

Avergae Prestress Force for the Cable (318.96T)

Y-axis: **Prestress Force (T)** — 150.00, 200.00, 250.00, 300.00, 350.00, 400.00

X-axis: **Distance from end1 (m)** — 0.00, 10.00, 20.00, 30.00, 40.00, 50.00, 60.00, 70.00, 80.00

Variation of Prestress Force after Initial Losses in Pure Vertical Cables in IC Wall
27K13 Prestressing System
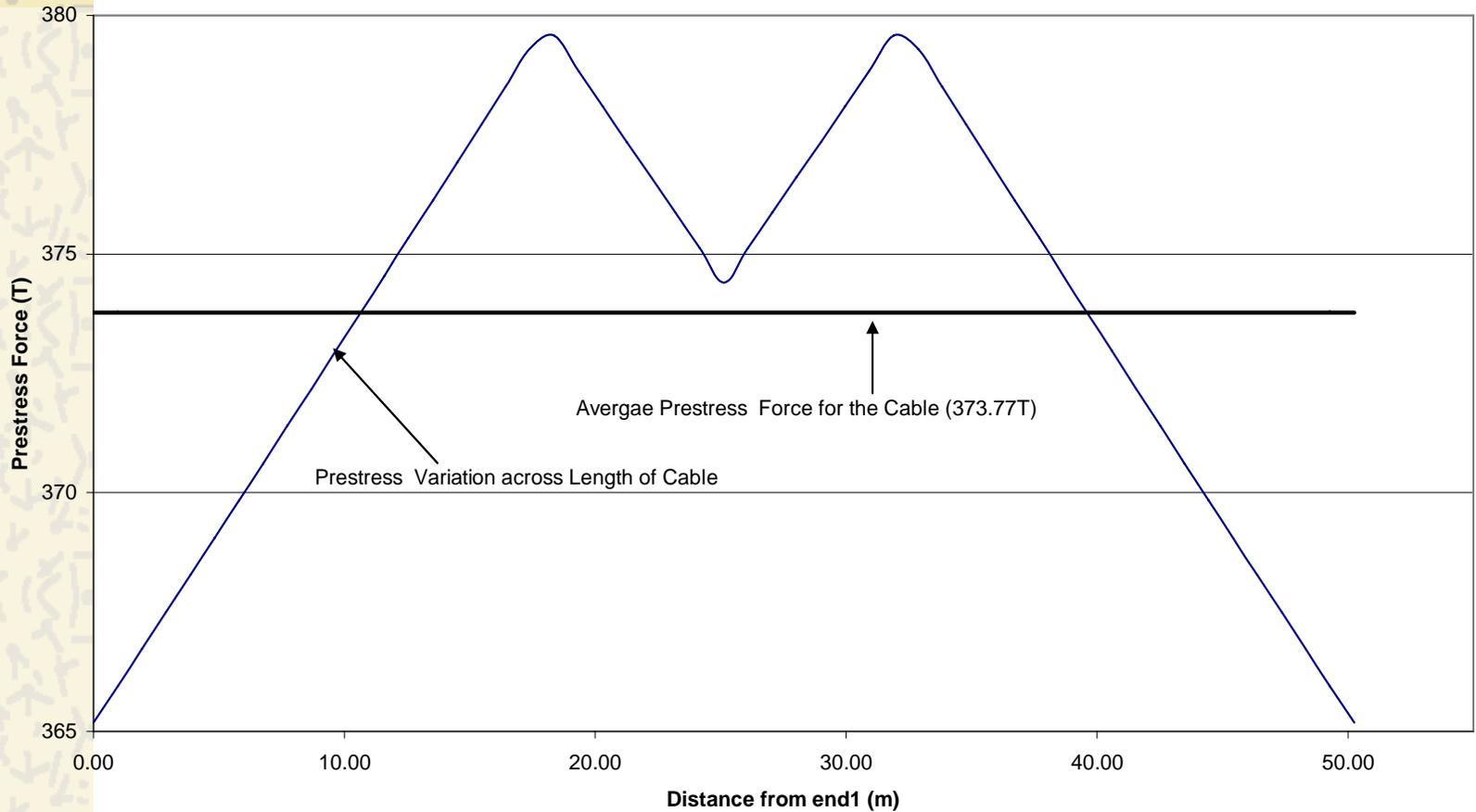
Avergae Prestress Force for the Cable (373.77T)

Prestress Variation across Length of Cable

Prestress Force (T) (y-axis: 365, 370, 375, 380)

Distance from end1 (m) (x-axis: 0.00, 10.00, 20.00, 30.00, 40.00, 50.00)

Variation of Prestress Force after Initial Losses for JO40 (type=1)
27K13 Prstressing System

Prestress Variation across Length of Cable

Avergae Prestress Force for the Cable (346.10T)

Prestress Force (T)

Distance from end1 (m)
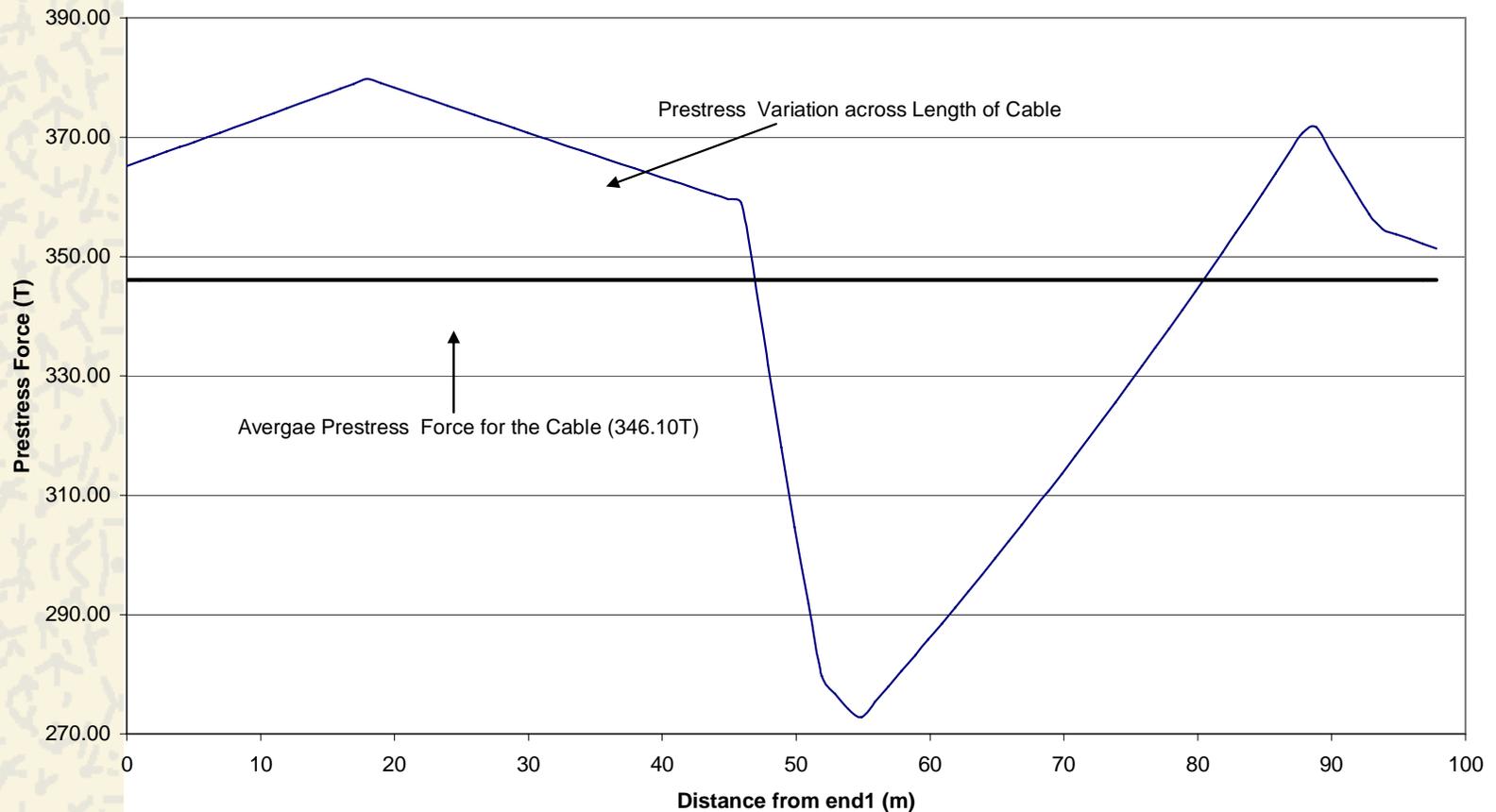
Long Term Prestress Losses as per Different International Standards

Long Term Losses are Calculated with respect to Average Prestress Available in Cables after Initial Losses

Data Used for Calculation

Grade of Concrete (cube strength)	45 MPa
Age of structure when long term losses are compared	40 years
	i.e., 14600days
Age of structure when drying started	7days
Age of structure at load transfer	67days
(Considering 7 days curing & 2 months of prestressing)	
Relative humidity	60%
Volume to surface ratio = Effective thickness of structure	650mm
Slump of concrete	120mm
% of fine aggregate to total aggregate	40%
Air content of concrete	2%
% Reinforcement considered	1.3%
with 2-25ϕ at top & bot. of the cable & 1-25 ϕ @ top & bot. in betn. Cables, cable spacing = 500mm & considering 50% prestress steel participation	

Data Used for Calculation

Modulus of Elasticity of Prestressing steel	1.95E+05MPa
Modulus of Elasticity of Concrete	As per codal requirement
Stress in concrete section due to prestress	12 MPa
Stress in concrete section due to dead load	1 MPa
Prestressing system	27K13 with low relaxation steel
C/s area of prestressing steel	2664.90 mm^2
Guaranteed ultimate tensile strength of the system	500 T
Prestress force after initial losses	340 T
1000 hour relaxation (ρ1000)	2.5 %

Long Term Losses
## (Shrinkage + Creep + Relaxation)

- AERB Containment Code (AERB/SS/CSE-1)
- CEB-FIP Model Code 1990
- Euro Code - ENV 1992-1-1 EC 2
- IS: 1343-1980
- BPEL-91
- Present design practice of NPCIL
- IRC: 18-2000
- Canadian Code - CAN3-A23.3-M84
- American code (ACI 209R)

Total Long-term Losses

Code	Long Term Prestress Losses (T)			
	Shrinkage	Creep	Relaxation	Total
AERB/SS/CSE-1	15.79	27.79	51.71	95.29
CEB-FIP MODEL CODE	15.79	26.46	25.85	68.10
Eurocode	Computation thru' common expression			63.06
IS 1343 : 1980	5.65	28.67	18.65	52.98
BPEL-83 / BPEL-91	8.81	34.08	10.42 ▶	51.57
Practice Followed by NPCIL	5.65	28.67	18.33	52.66
IRC 18 2000	8.57	24.94	8.50	42.01
CAN3-A23.3-M84	Computation thru' common expression ▶			36.07
ACI 209R - 92	0.60	16.85	9.42	26.87

Variation of Long Term Prestress Losses with time
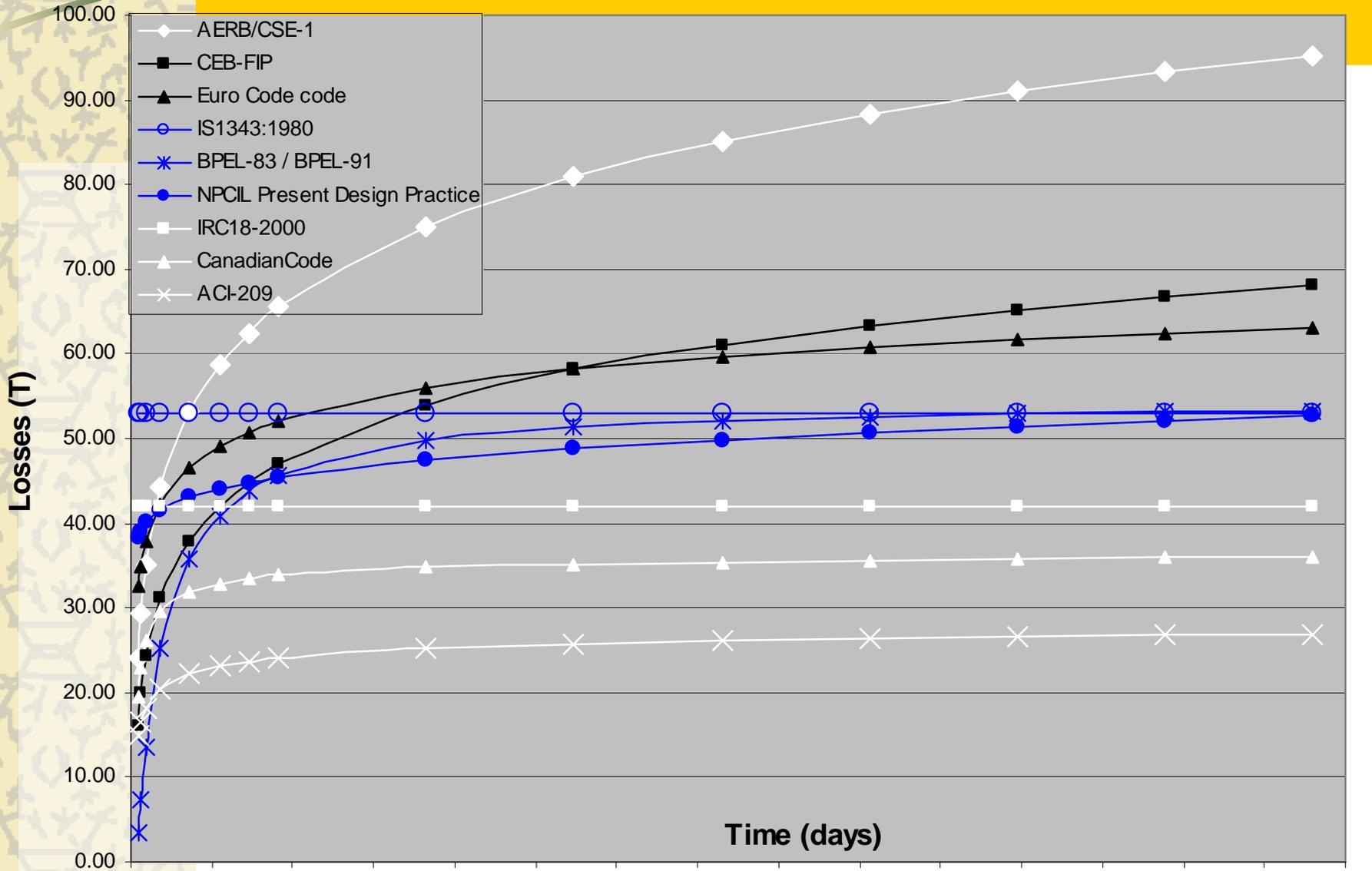
CONCLUSION OF THE STUDY

- The predictions by NPCIL present practice, IS:1343-1980, IRC:18-2000 and BPEL match very closely

- CEB-FIP and EURO code predict long-term losses very closely

- Long term pre-stress losses show signs of stabilisation in around 20 years

Thank You