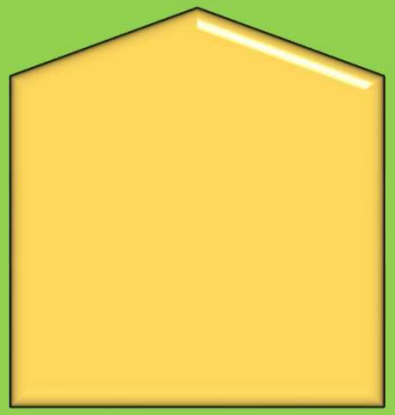
Advanced Programme - Planning, Design _ Construction of Long Span Bridges- (Batch I) - 22

SUSTAINABLE DESIGN OF LONG SPAN BRIDGES



National Rural Infrastructure Development Agency

Ministry of Rural Development

Engineering Staff College of India (ESCI)

Hyderabad

Lecture 4

SUSTAINABLE DESIGN OF LONG SPAN BRIDGES

TOPICS

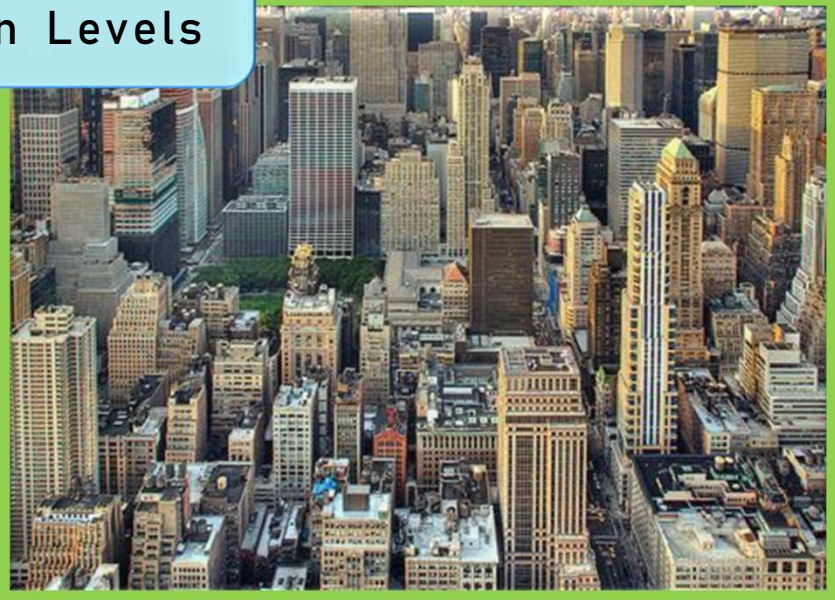
- INTRODUCTION
- MATERIALS
- ANALYSIS & DESIGN
- BRIDGE AESTHETICS
- CONCLUSION

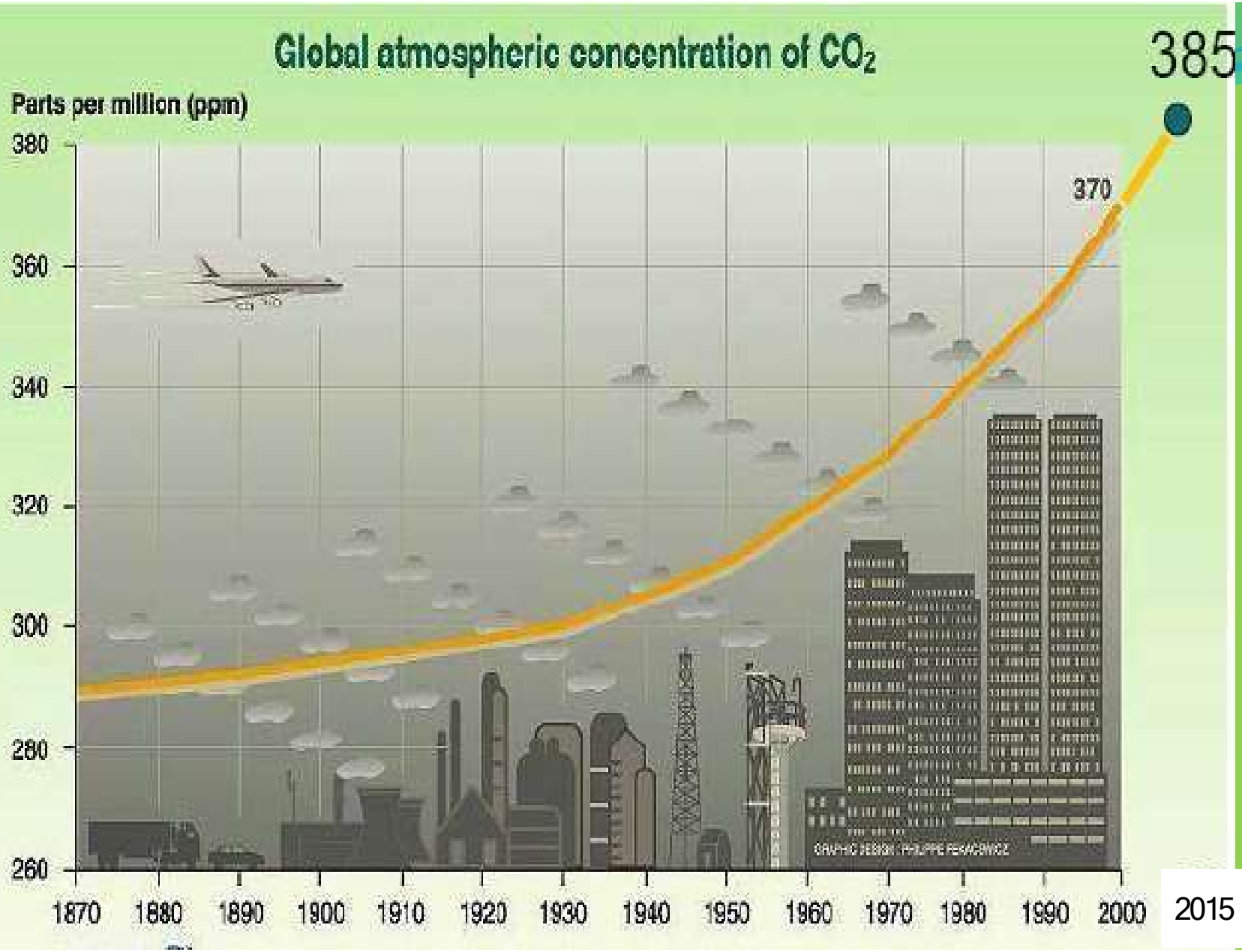
What is Sustainability?

Definition of Sustainable Infrastructure

Designing, Constructing and Operating of Infrastructure without damaging social, economic and ecological processes required to maintain human equity, diversity and the functionality of natural systems

Increased Pollution Levels




Global atmospheric concentration of CO_2
Parts per million (ppm)
380
360
340
320
300
280
260
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
370
385
2015


“Nora” the polar bear!

GLOBAL TREND NOW

COST

NEW DIMENSION

SOCIO-CULTURAL

ENVIRONMENT

SUSTAINABLE!

LCC

- Construction
- Inspection & Maintenance
- Dismantling & Recycling

TOMB-TO-WOMB

- HARMONY with local values & heritage
- Environment & Ecology
- 360^0 Safety – All modes
- Future-Proofing
- Multi-purpose

LCA

- CO_2 emissions at each stage from material extraction
- Local people
- Local heritage

FACTORS INFLUENCING SUSTAINABILITY

SURVEY & PLANNING

- SURVEY
- OPTION STUDY
- OTHER USERS
- PLANNING FOR FUTURE

CONFIGU-RATION

- SPAN
- PYLON SHAPE
- LANES
- DECK TYPE

IMPACT ON ENVIRONMENT

- CO_2 EMISSIONS
- CARBON FOOT-PRINT
- POLLUTION LEVELS

SOCIAL-CULTURAL

- LOCAL PEOPLE
- LOCAL CULTURE
- TOURISM POTENTIAL

DESIGN & CONSTRUCTION

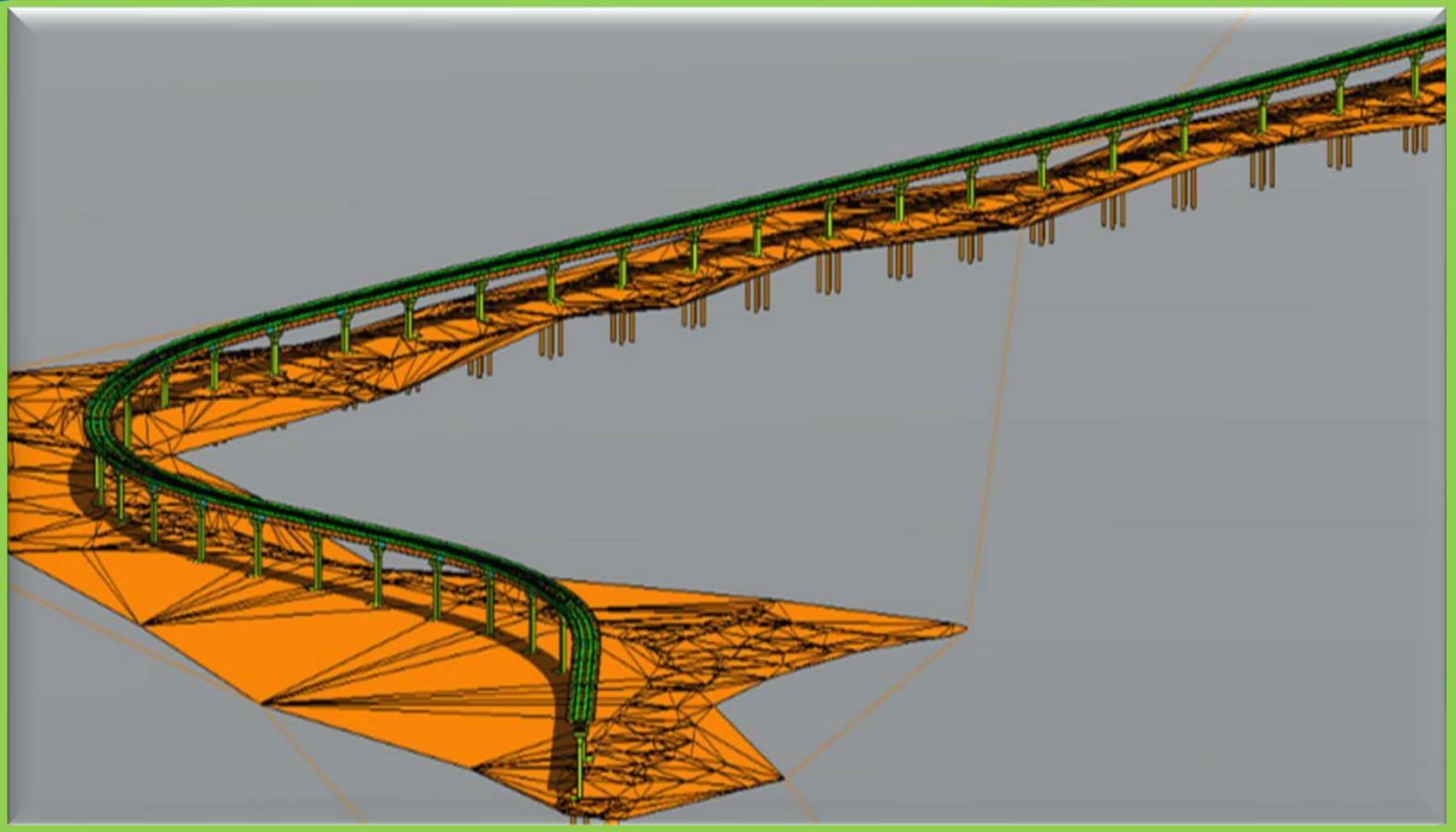
- MATERIAL
- ANALYSIS
- CONSTRUCTION
- MAINTENACE

Modern Survey Techniques

Terrestrial

Air-borne

LiDAR – Light Detection and Ranging

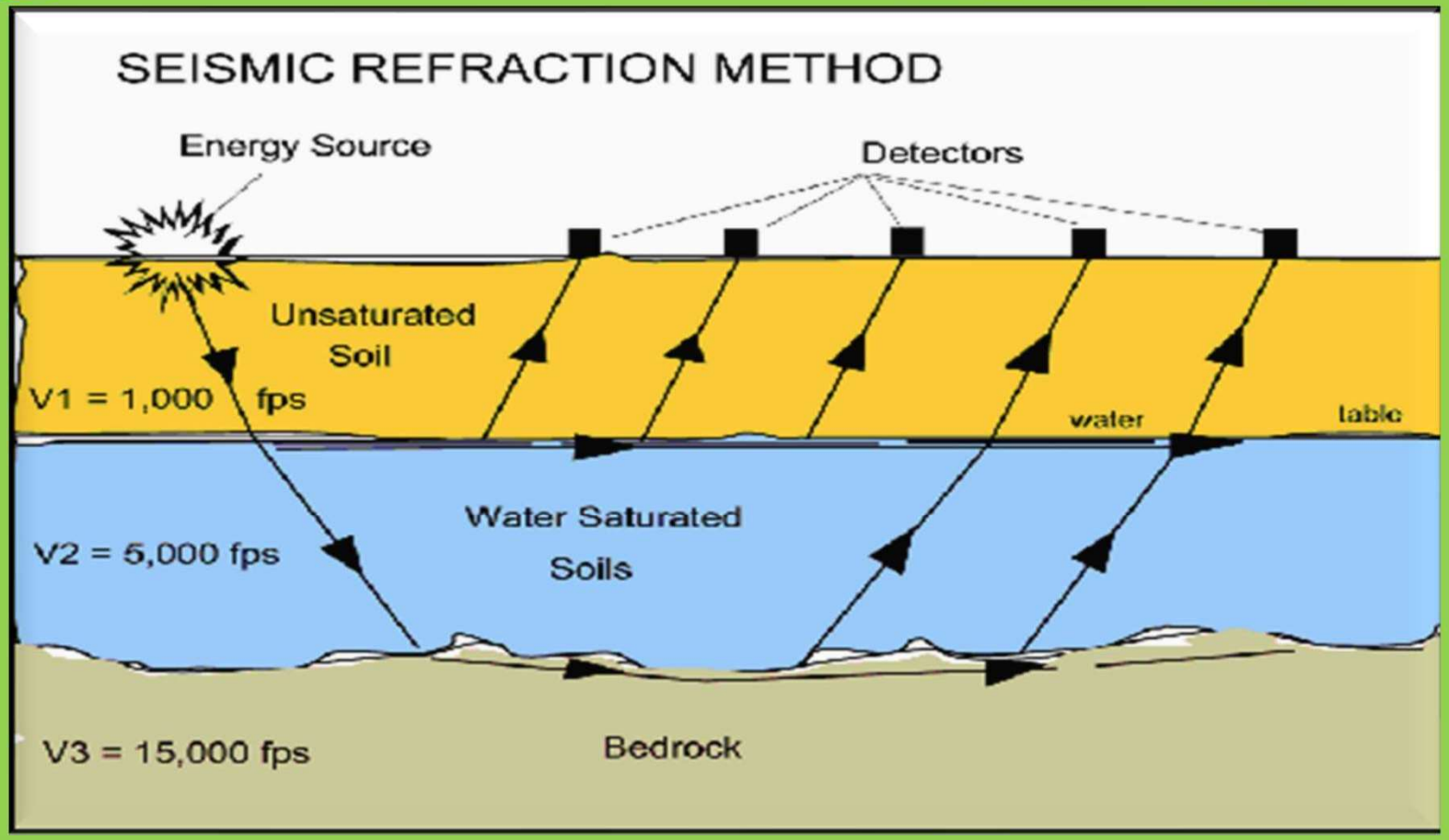


Railway or Highway Design

Conventional Geotech investigation

Pollution, accuracy

Non-intrusive Geotech investigation



Seismic Wave Testing

Forth Replacement bridge, Scotland

Need for additional bridge

Existing steel bridge outlived its life

2nd bridge has reached

saturation Increasing road traffic

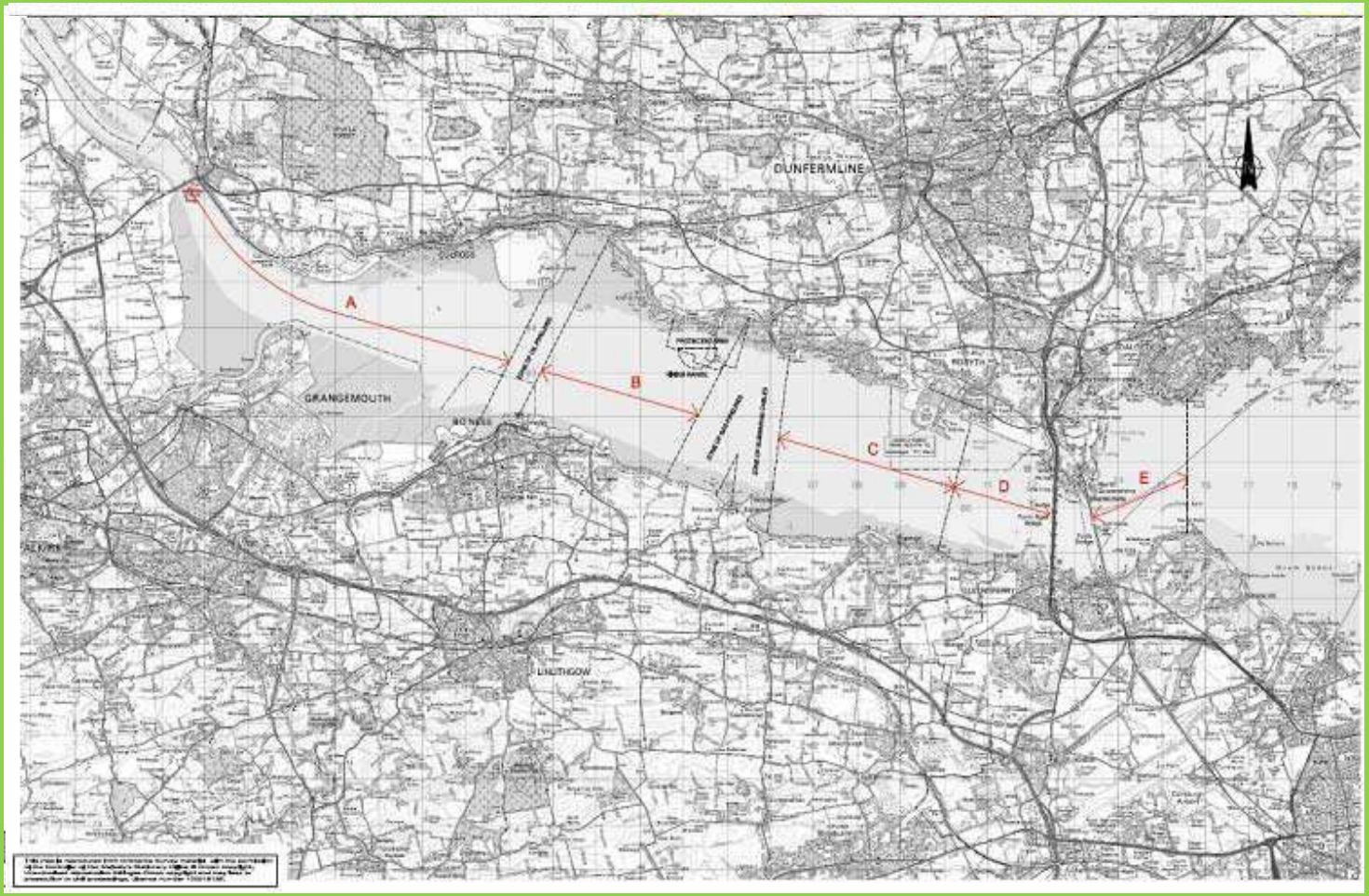
Connectivity to more regions

General Tendency: New bridge adjacent to existing

Forth Replacement bridge, Scotland

Five options identified

Multi-aspect studies



Comparison of alternatives

Table 7.1 Monetised Summary of Costs and Benefits (£millions, 2002 values and prices)

Corridor	C	D	D	D	E
Crossing Type	Tunnel	Tunnel	Cable-Stayed Bridge	Suspension Bridge	Tunnel
Present Value of Benefits (PVB)	4,655.6	5,303.1	6,026.1	6,026.1	6,317.1
Present Value of Costs (PVC)	-2087.4	-1967.7	-1,397.3	-1,574.9	-2,172.2
Net Present Value (NPV)	2568.2	3,335.3	4,628.8	4,451.1	4,144.9
Benefit to Cost Ratio (BCR)*	2.23	2.70	4.31	3.83	2.91

*ratio, not monetary value

Finally selected alternative

Sustainable!

Sea-Cliff bridge,
Australia

Respecting Nature

Linn Cove Viaduct, USA

If Nature is not respected

Configuration

SPAN

Dimensions
Type
Other Modes
Clearances

PYLON

Dimensions
Shape
Material
AESTHETICS

LANES

HOV Lanes
Other Modes
Pedestrian/
Cycle lane

DECK

Shape
Material
Launching

SPAN

- Hydrological requirement
- Navigational requirement
- Deep gorge
- Poor geology
- Economy

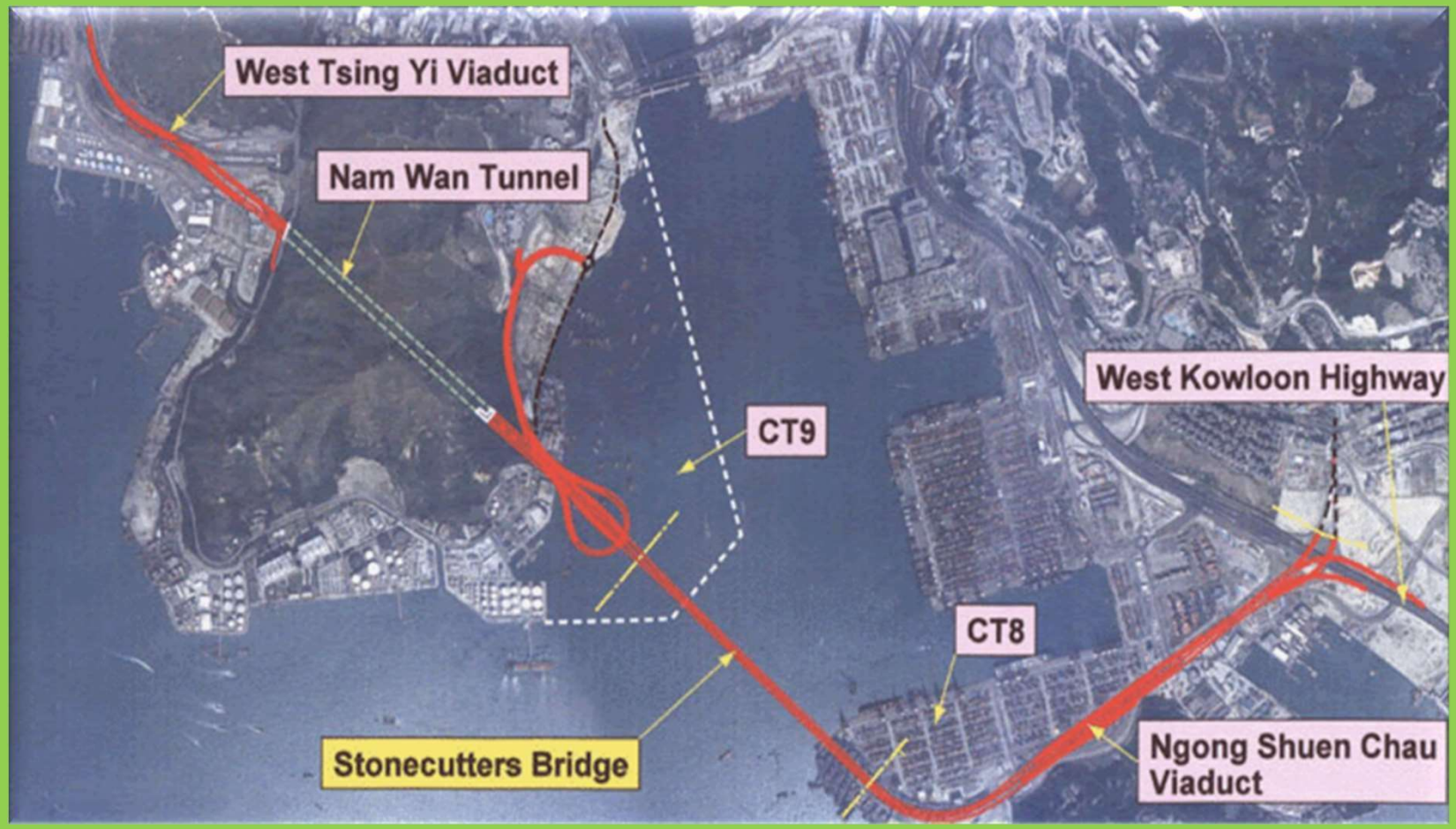
360⁰ SAFETY

Navigational requirement

PYLON MATERIAL

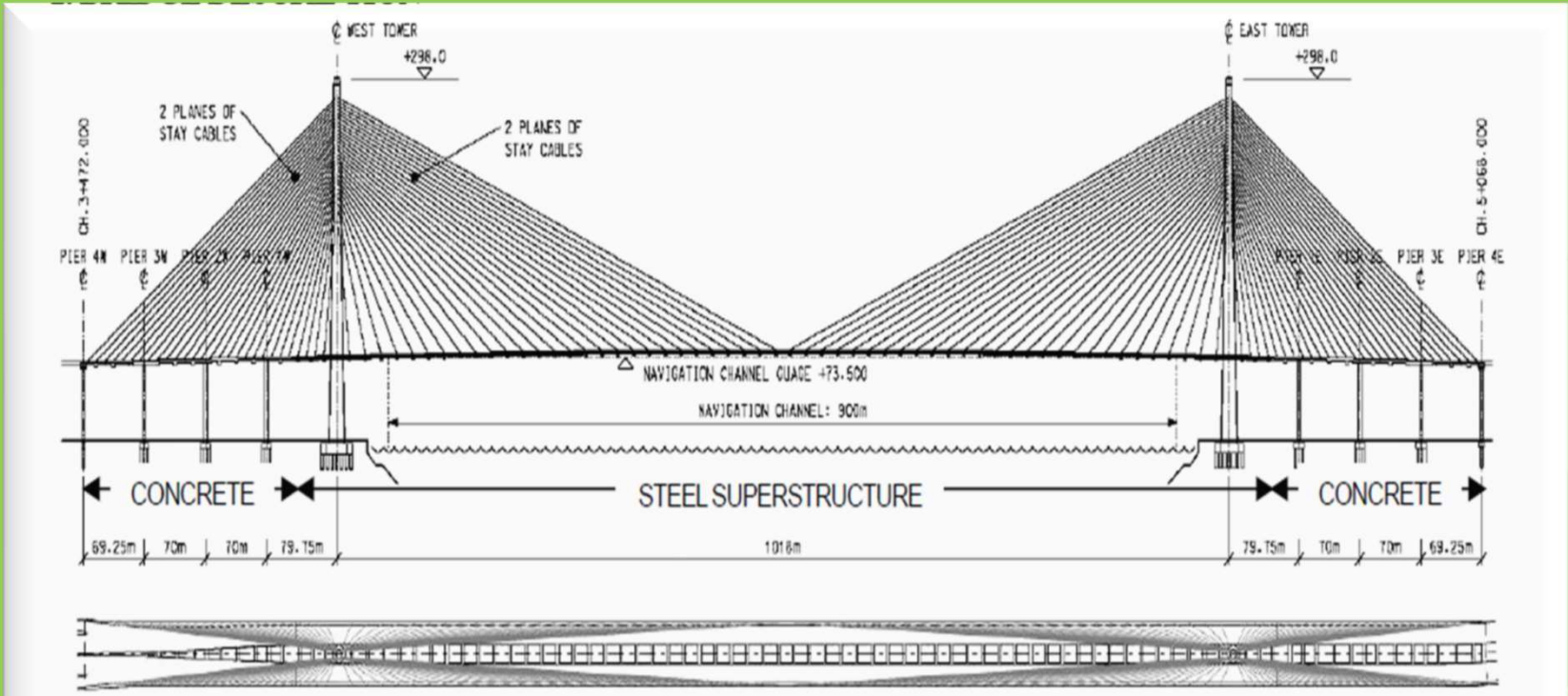
- Sustainable
- Representative
- Maintainable

Stonecutters' bridge, Hong Kong



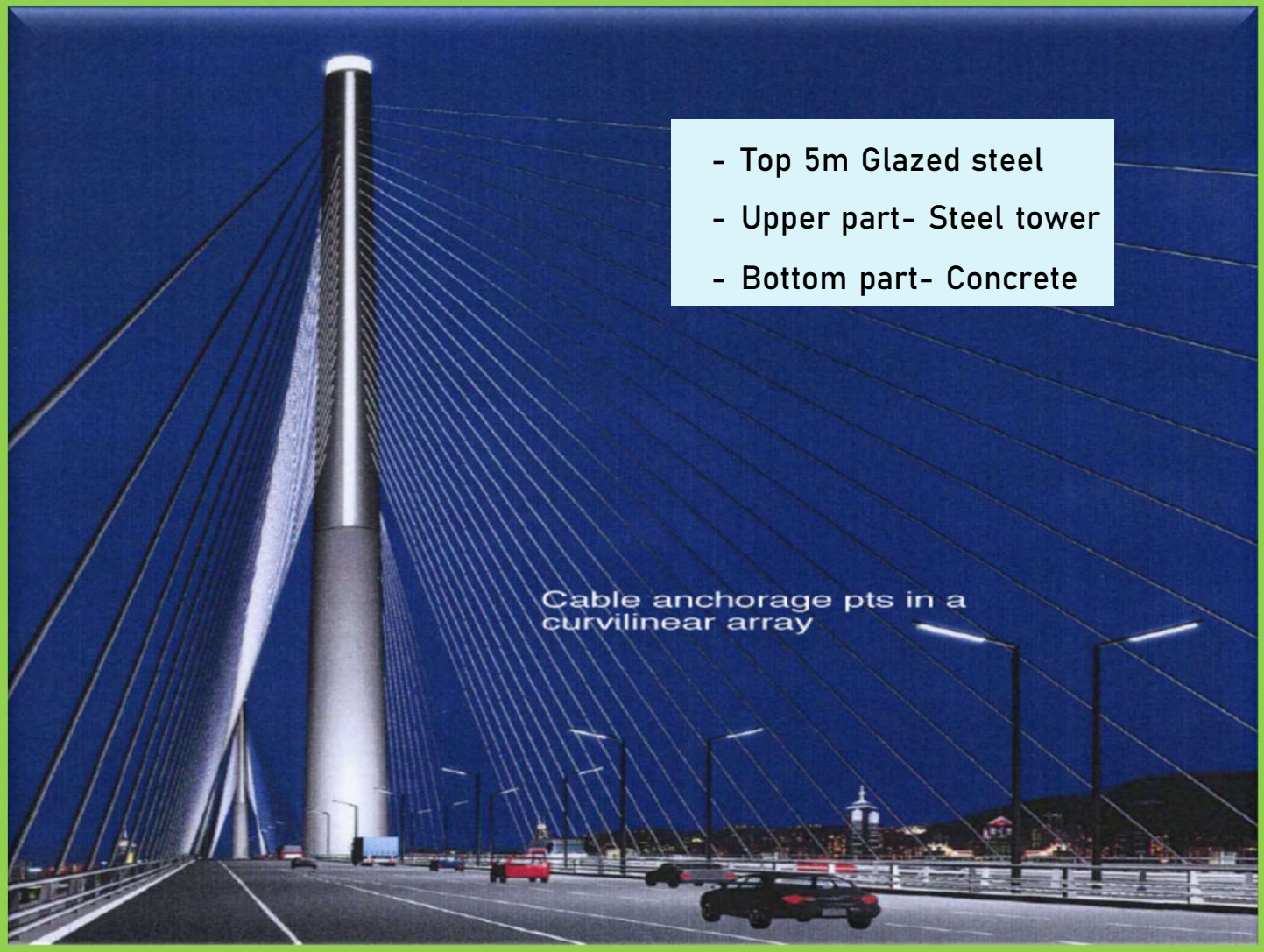
International Design Competition

Winning Design



<Fig. 2> Elevation and Plan

Composite material



LANES

For ‘HOV’

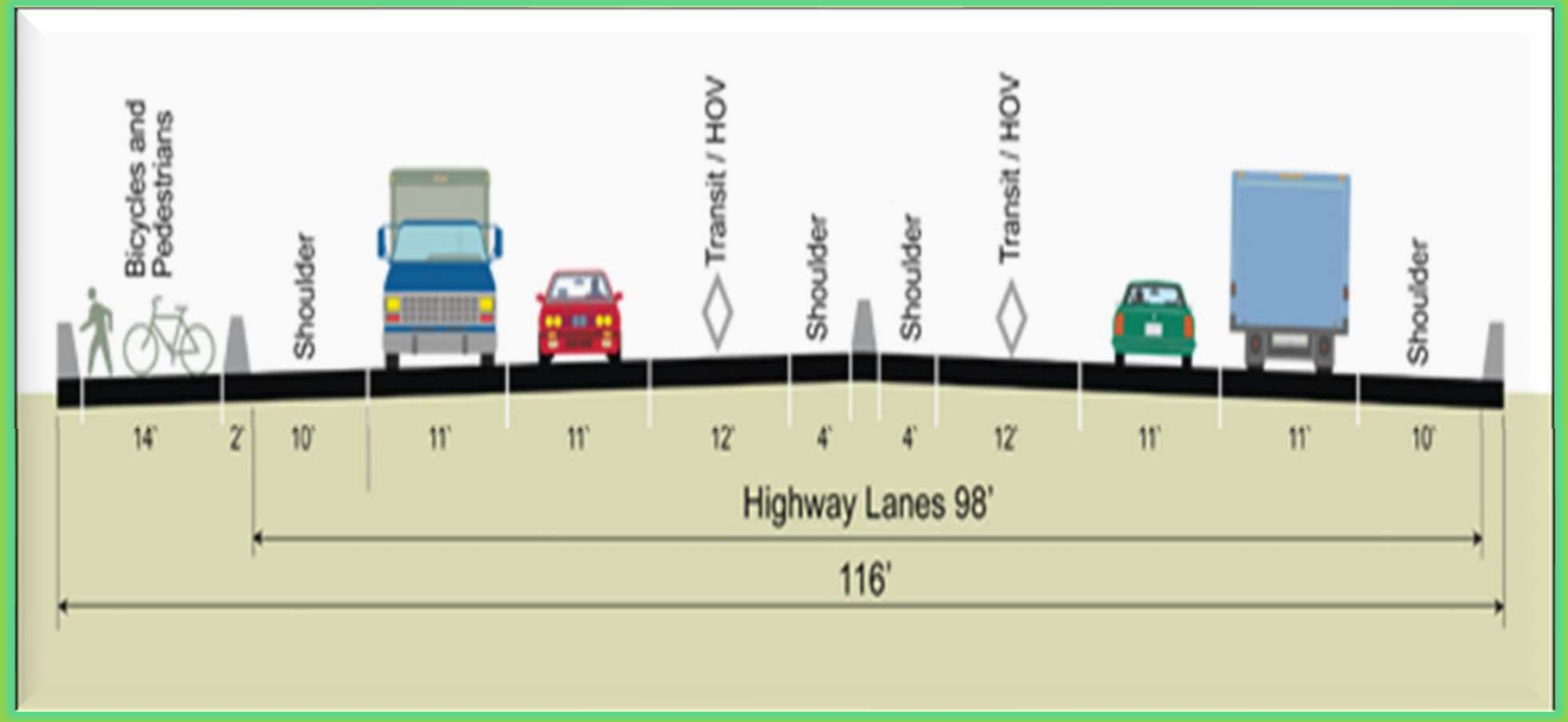
Other Modes

Pedestrians

Cycling

Lanes

Cooper Bridge, USA



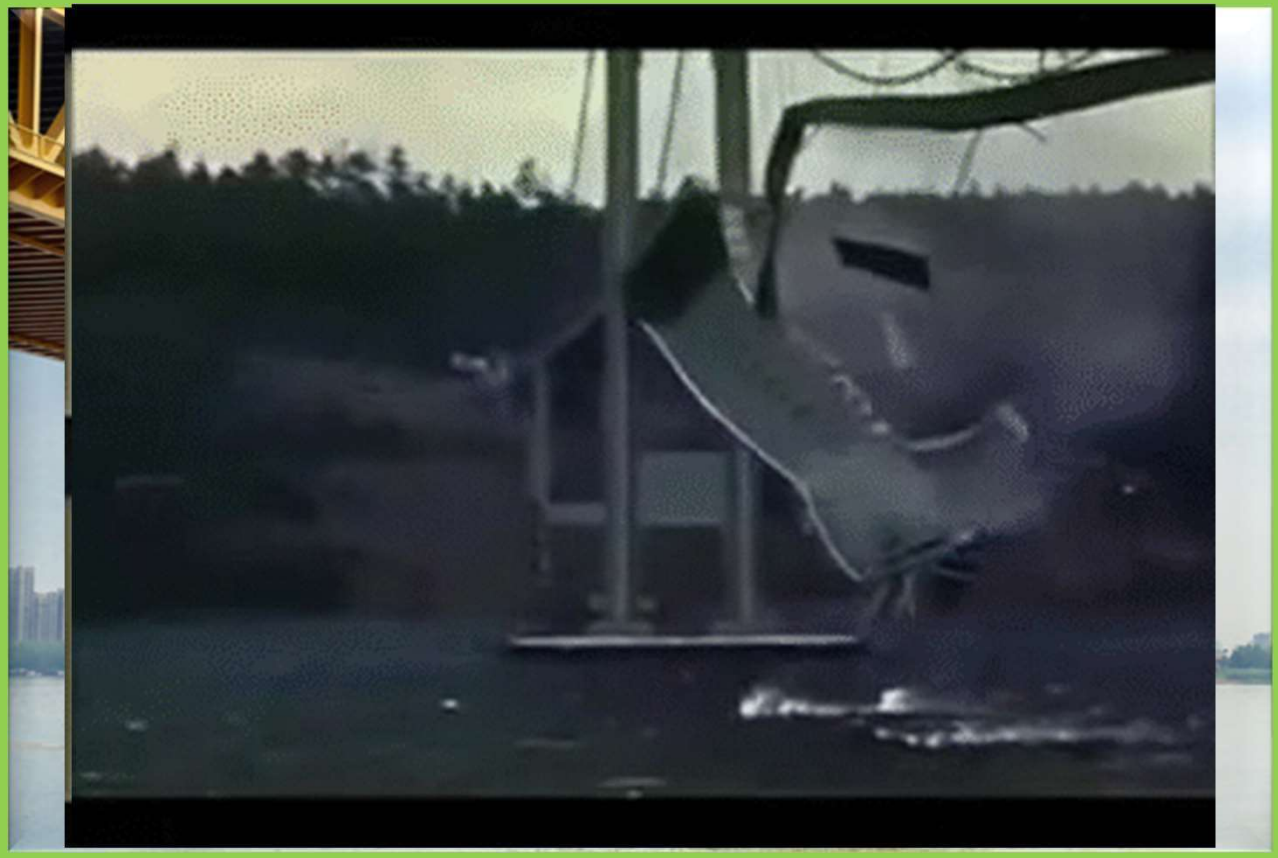
Lanes for 'HOV' (Metro/ Tram)

Golden Gate bridge, USA

DECK

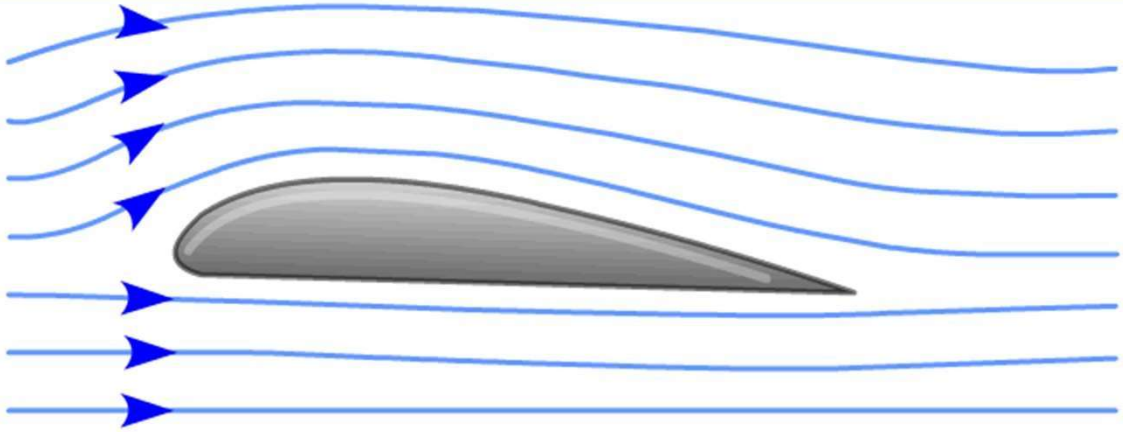
Shape
Material
Stability

SHAPE



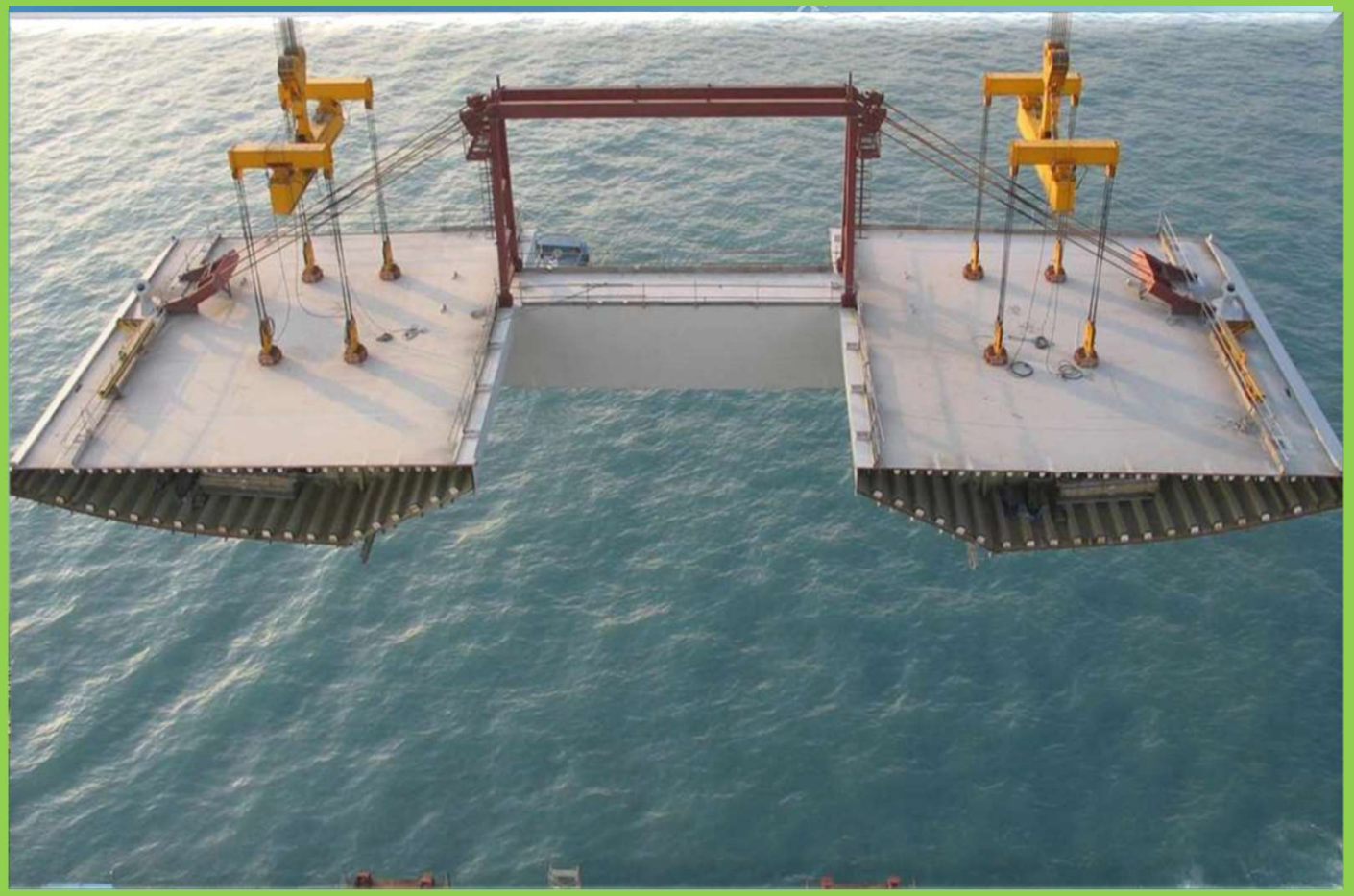
Conventional

Aerodynamic



No vortex shedding

Lesser weight



LCA of CO_2 emissions

CO_2 released during:

- Material extraction
- Transportation
- Consumption
- Service/ Maintenance
- Dismantling

Some more examples..

CONCRETE

- Bacterial
- Internally cured
- Polymer Modified
- Self Compacting
- Recycled aggregate

STEEL

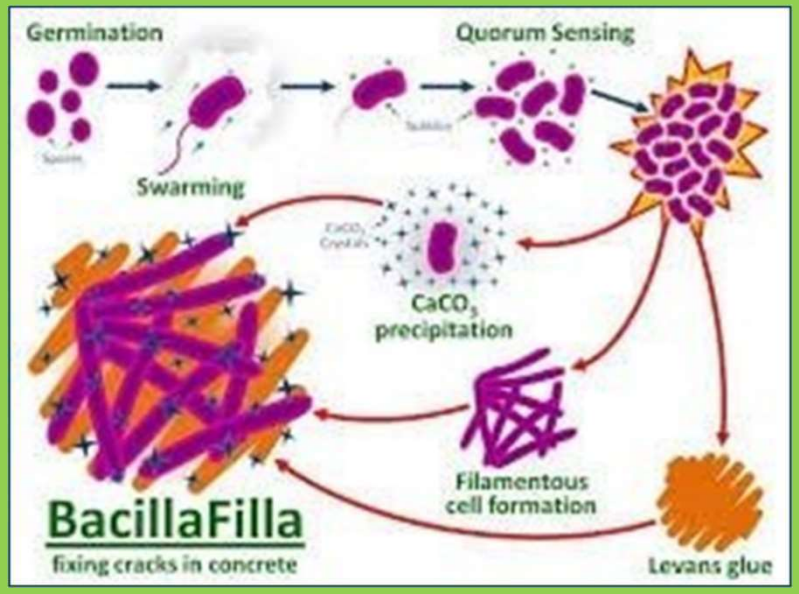
- Weathering
- Stainless
- High Strength
- Orthotropic

OTHERS

- Composite
- Recycled Plastic
- FRP Deck
- Aluminium alloy
- Corrugated Web

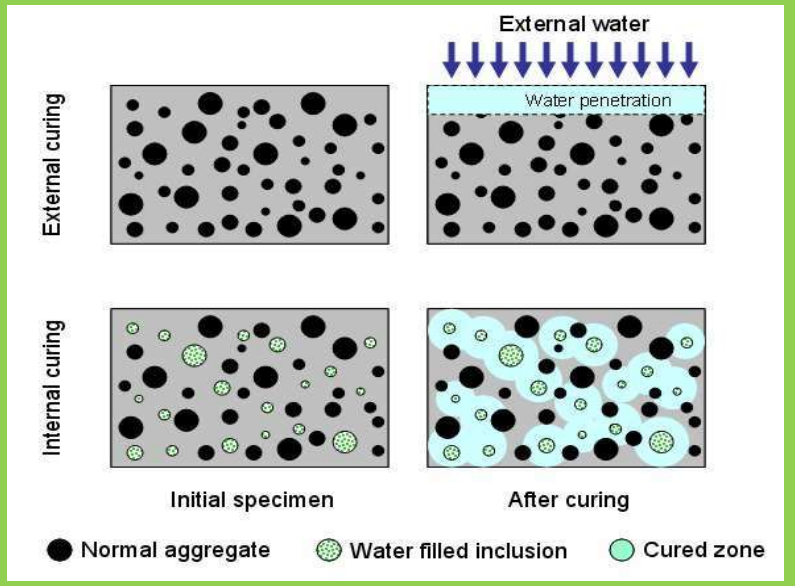
CONCRETE

BACTERIAL CONCRETE



Self-Healing Concrete

INTERNALLY CURED



Pre-Wetted LWA, Absorbent Polymers, Natural Fibres

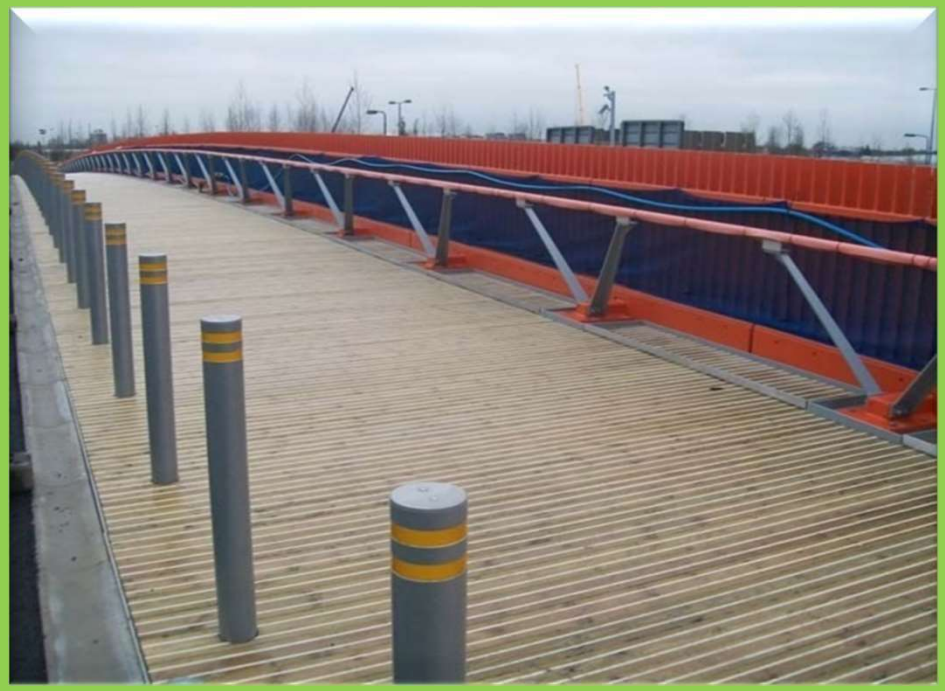
SELF COMPACTING CONCRETE

Max Slump

NO Sound
NO Vibration

RECYCLED

RECYCLED PLASTIC



LIGHT WEIGHT

RECYCLED AGGREGATE

BRIDGE ABUTMENT

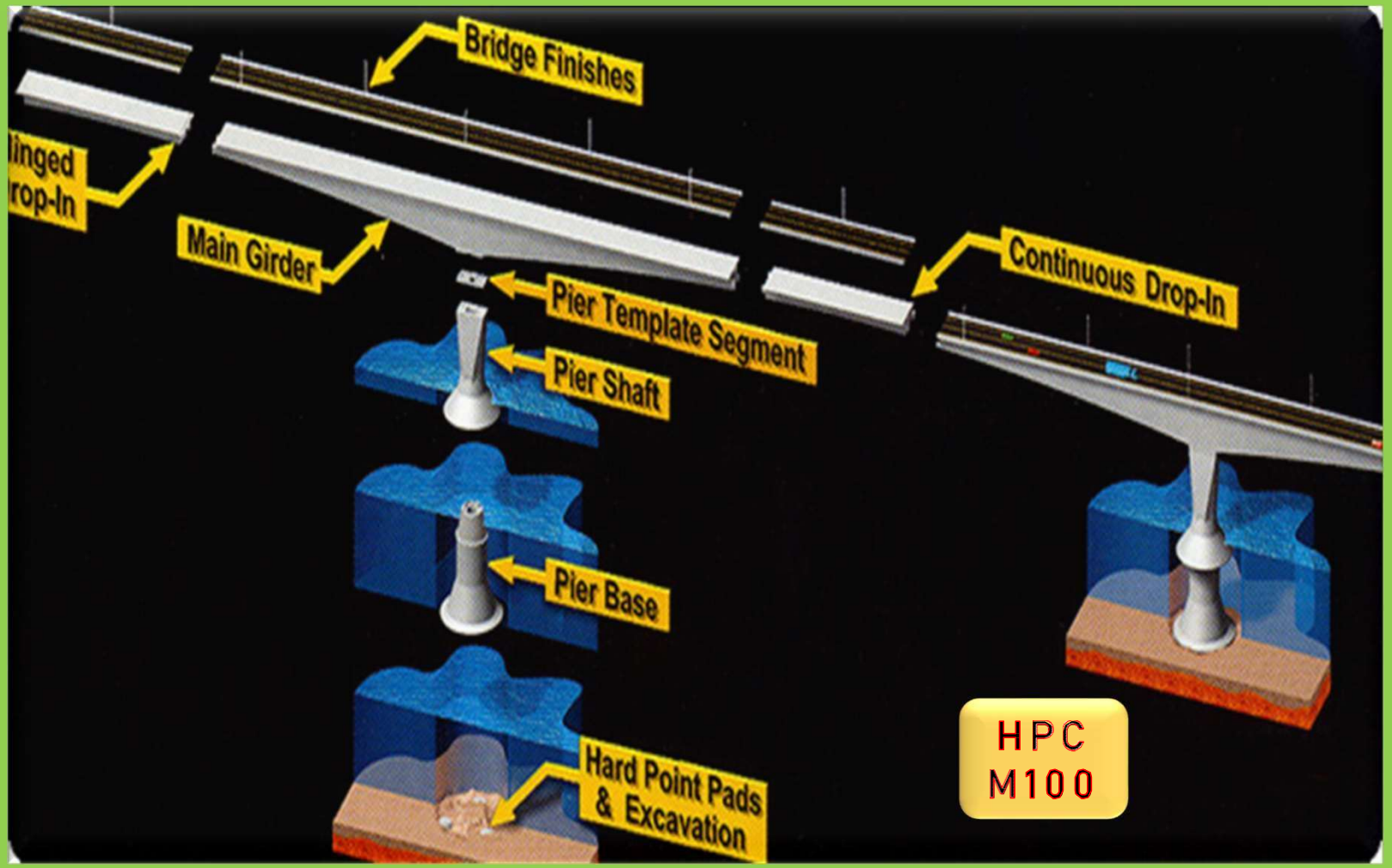
CONSTRUCTION PRACTICES

- Fast Track Construction
- Precast/ Pre-fabricate
- Mechanization
- Material & techniques

CONFEDERATION BRIDGE, CANADA

- Delicate marine life
- Sub-zero temperatures
- 12.9km long
- Navigation

TOTAL PRE-CASTING



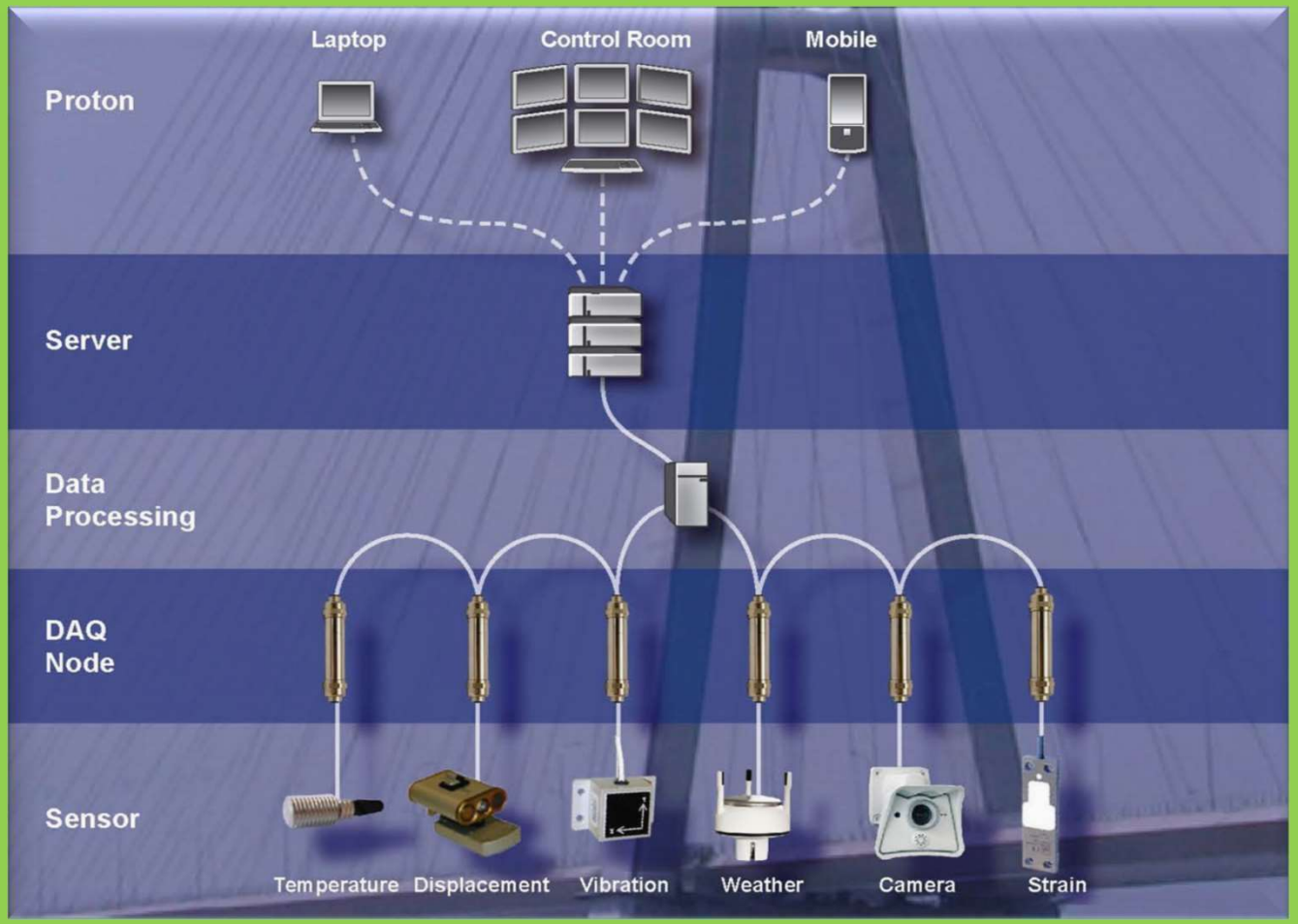
Precast Yard

Launching of elements

Instruments based

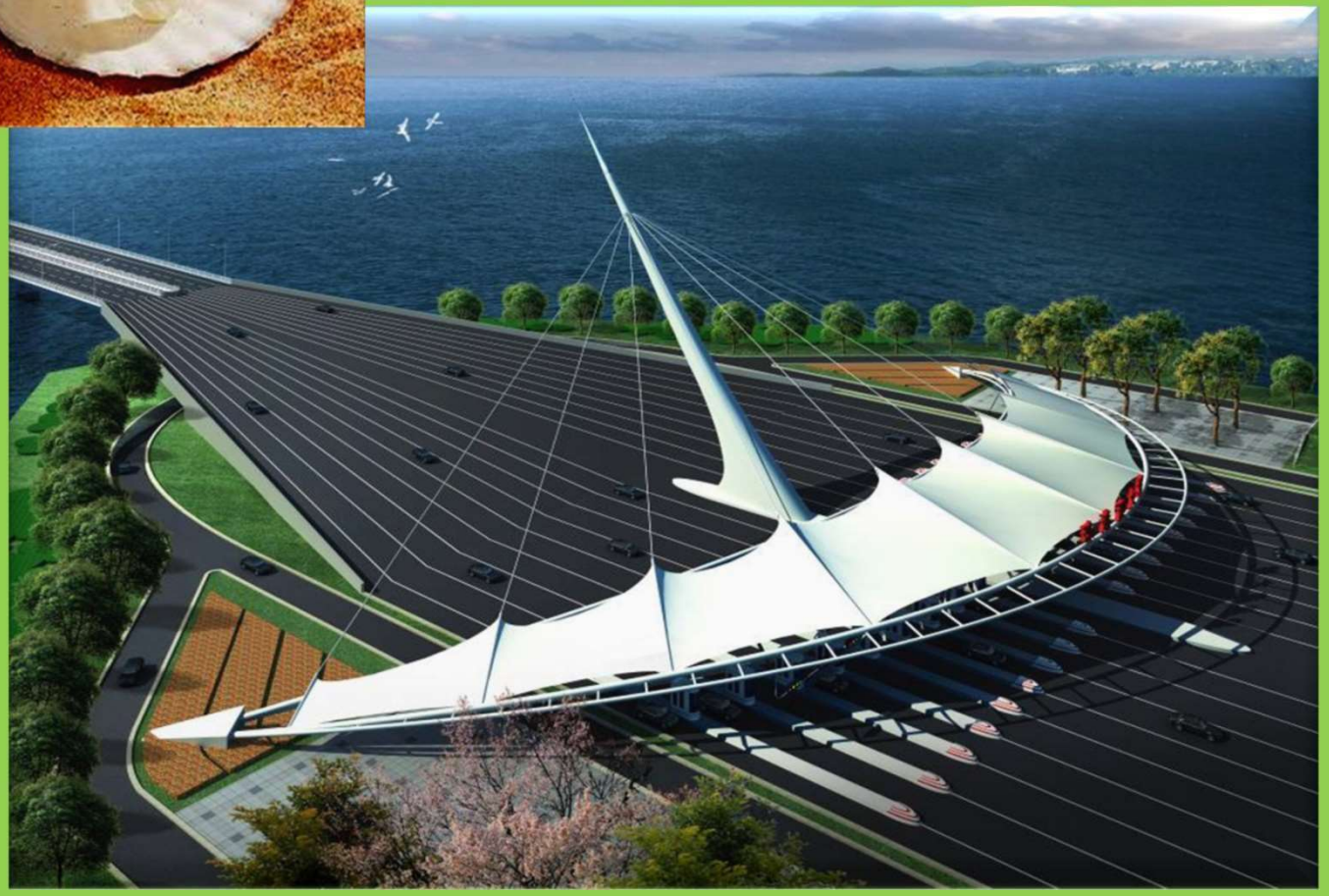
BRIDGE IS A LIVING ENTITY!

SHM by instruments



REMOTE STRUCTURAL HEALTH MONITORING

Entrance Plaza



Swing bridge

Hull bridge, UK

Mall inside!

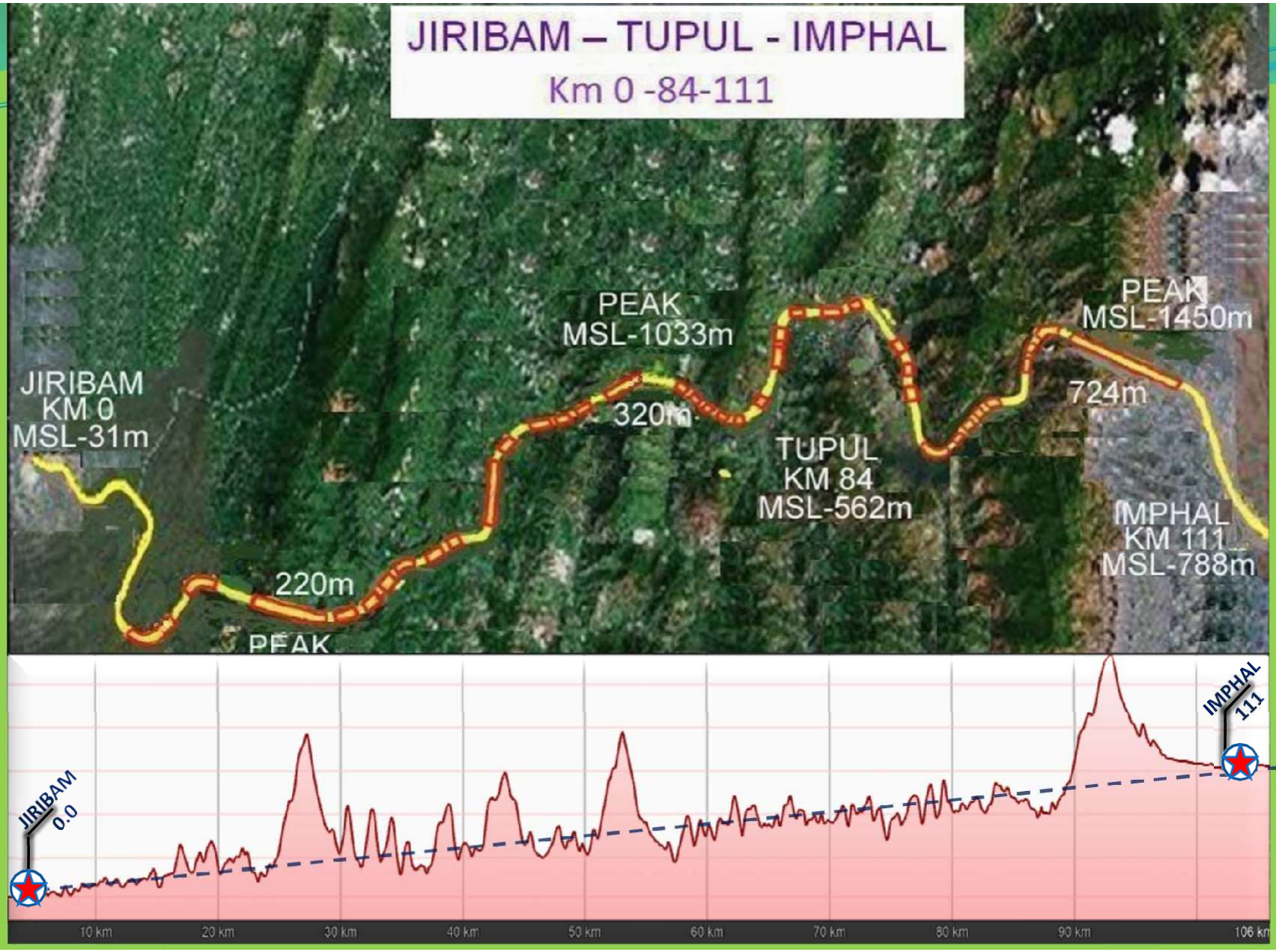
Xinvei valley, Vietnam

Butterfly valley

Adopt Sustainability !

NORA is happy!

My contribution to Sustainability


JIRIBAM – TUPUL - IMPHAL
Km 0 -84-111
JIRIBAM
KM 0
MSL-31m
220m
PEAK
PEAK
MSL-1033m
320m
TUPUL
KM 84
MSL-562m
PEAK
MSL-1450m
724m
IMPHAL
KM 111
MSL-788m
JIRIBAM
0.0
IMPHAL
111
10 km
20 km
30 km
40 km
50 km
60 km
70 km
80 km
90 km
106 km

New Tallest Bridge at Imphal, India: 141m high!

Qutab Minar

WASTE RECYCLING & GREEN CONSTRUCTION

EXCESS SOIL CONVERTED INTO SOIL CEMENT BLOCKS RE-USED FOR SLOPE PROTECTION

Waste soil

Water contamination

Solution Developed

- SOIL-CEMENT BLOCKS
- Only 5% cement
- Strength: 15MPa
- IS:1725-1982
- Reused in place of bricks

Reduction in CO_2: 74,700t (LCA Analysis)

Cost Savings: Rs.110cr (LCC Costing)

Soil- Cement Blocks

Only 5% cement

Machine to convert Soil into Bricks

Economical
Environment friendly
Employment to Locals
Aesthetics

Promoting local heritage

Stations depicting local architecture

C S R

Free Medical Camp for locals

C S R

Free Food during medical camp

My team- my family!

Completed section

NATIONAL AWARD (JAN, 2020)