



LESSONS FROM UGANDA'S FIRST CABLE-STAYED BRIDGE

Design Review, Construction Supervision, and the Role of the Employer's Own Representative

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THE SOURCE OF THE NILE BRIDGE ·

AGENDA

What We Will Cover

60 minutes · Lessons from Uganda's first cable-stayed bridge

1.	Welcome & Introduction	3 min
2.	Project Background & Bridge Overview	7 min
3.	Design Review & Constructability	13 min
4.	Construction Supervision & Delivery	11 min
5.	Role of the Employer's Representative	4 min
6.	Contract Administration & Governance	4 min
7.	My Bottom Line	7 min
8.	Questions & Discussion	11 min



01

Welcome & Introduction

3 minutes



Greetings from the Eastern Region of Africa



I am Arthur Mijumbi, a Civil Engineer from Uganda.



I served on the Source of the Nile Bridge as the Employer's own representative on site.



Today: one bridge, honestly told, what worked, what nearly failed, and why the employer's side of the table decides both.

*For those who might not be aware of where Uganda is located, **here is the view.***



The world view, Uganda marked in East Africa.



Africa up close, Uganda astride the Equator, source of the River Nile.

02

Project Background & Bridge Overview

7 minutes



One Ageing Crossing Carried a Nation's Trade

90%

of Uganda's trade volumes

moved over this single crossing to the port of Mombasa

1954

Nalubaale Dam / Bridge opened

the only Nile crossing at Jinja on the Northern Corridor

50+ yrs

design life exceeded

visible age deterioration despite occasional repairs

Any closure would have meant huge economic impact and social disruption to Uganda and regional trade, the corridor links Rwanda, Burundi, Eastern DRC and South Sudan to the sea.



May 2016: flooding and congestion, the daily reality on the old crossing.



The Nalubaale Dam crossing and project site at Jinja.

Three Objectives on the Northern Corridor



The Northern Corridor multimodal network (Source: NCTTCA).



Economic growth & integration

Guarantee people and trade movement between Uganda and Central African neighbours on the NCR.



Safety of the NCR system

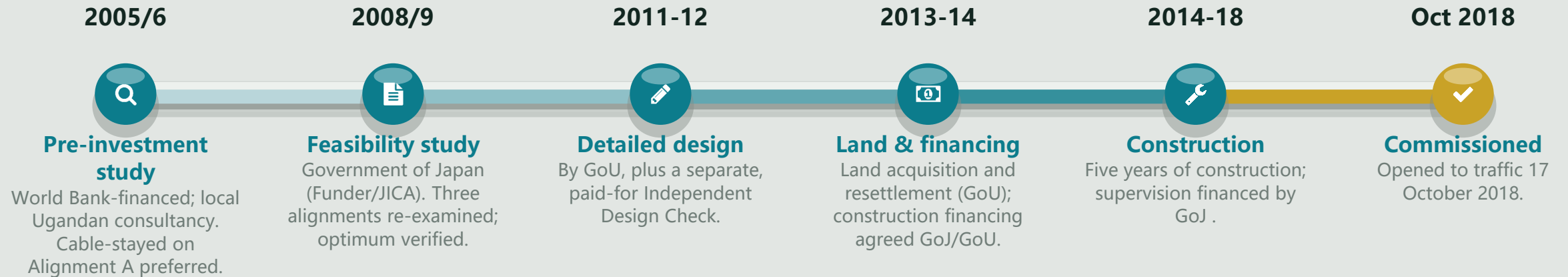
Relieve traffic loading from the deteriorating Nalubaale Dam/Bridge, in service since 1954.



Tourism

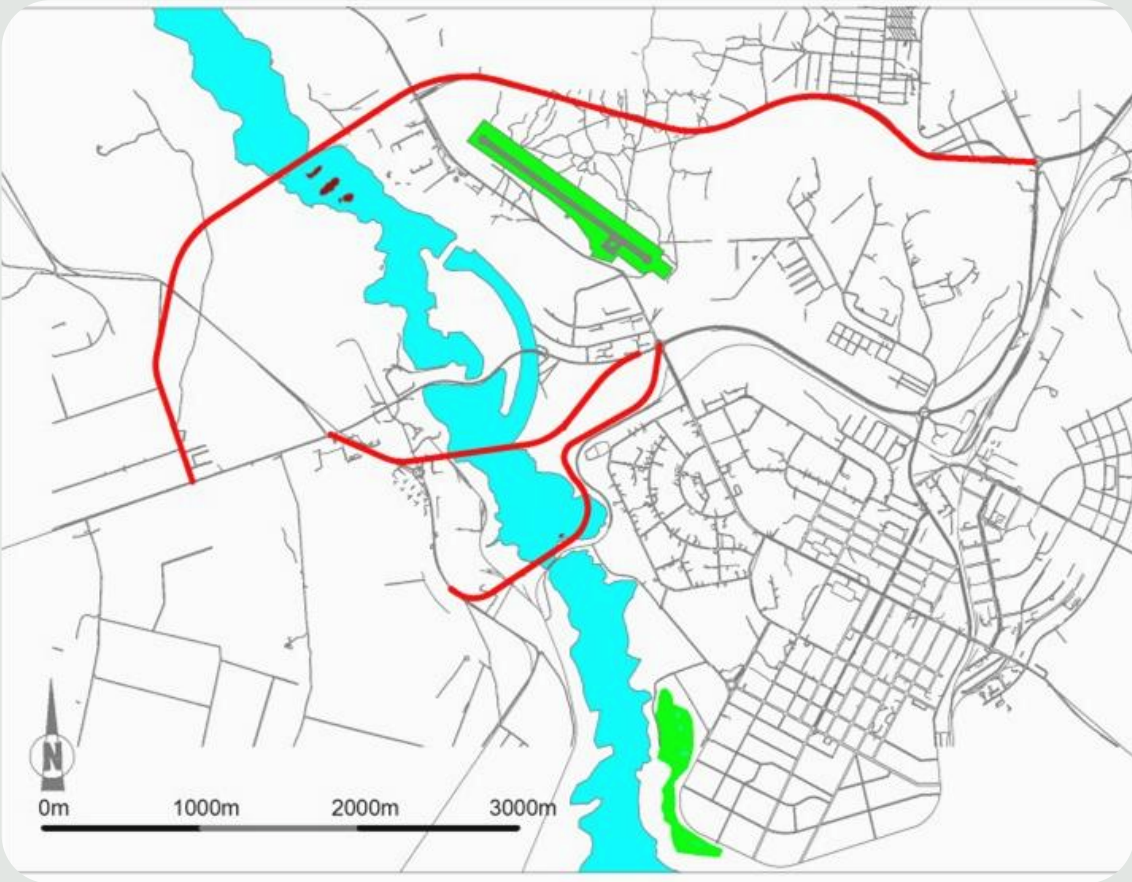
Add an iconic signature bridge in this picturesque location at the source of the Nile.

Thirteen Years of Preparation Before the Ribbon



Options were tested, retested, and independently checked before commitment. Sixty percent of Africa's project delay drivers are planted before construction begins, this project spent its best engineering at the front end.

Three Alignments, Five Bridge Forms, One Answer



Example of alignments at site (Source: FS).

Alignment	Position	River width	Verdict
A	0.5 km upstream of Nalubaale Dam	300 m	SELECTED: keeps piers out of the Nile
B	1.2 km upstream, close to the railway bridge	170 m	Rejected
C	1.8 km downstream of the dam	250 m	Rejected

Five structural forms were tested across the alignments, box girder, cable-stayed, arch-spandrel. **The cable-stayed option on Alignment A was the only way to stay out of the river entirely, and returned highest in financial terms. The WB study and funder’s feasibility reached the same conclusion independently.**

A 525 m Signature Crossing of the Nile

525 m

PC cable-stayed bridge

inverted-Y pylon, single-plane stays

290 m

main span

spans 135 + 290 + 100 m

2 km

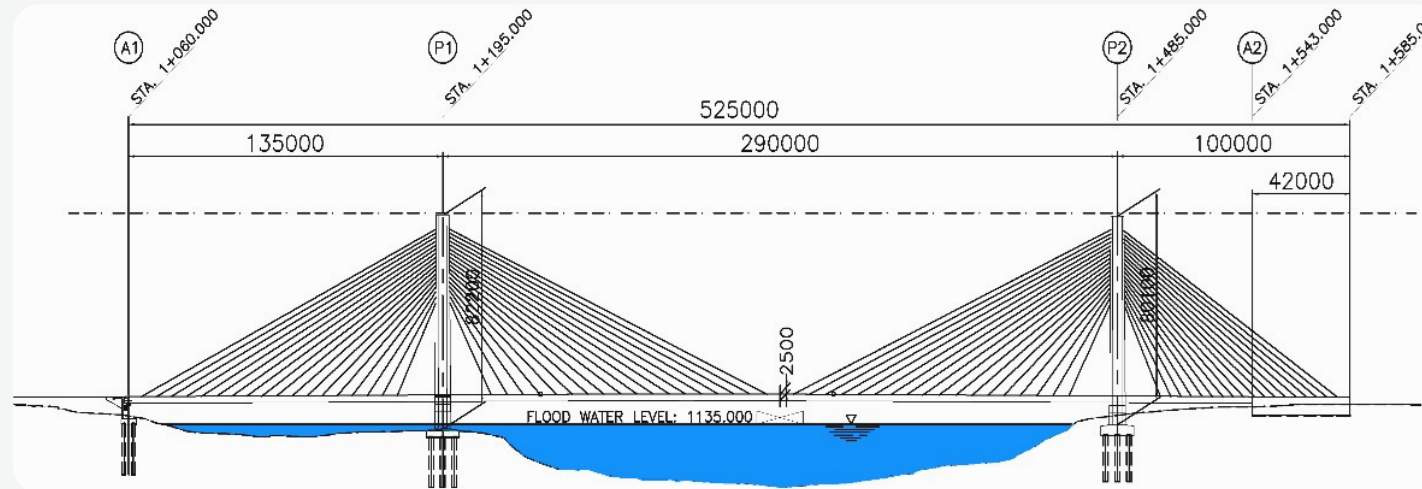
access roads

785 m Kampala · 1,044 m Jinja

0

piers in the River Nile

the decisive design criterion

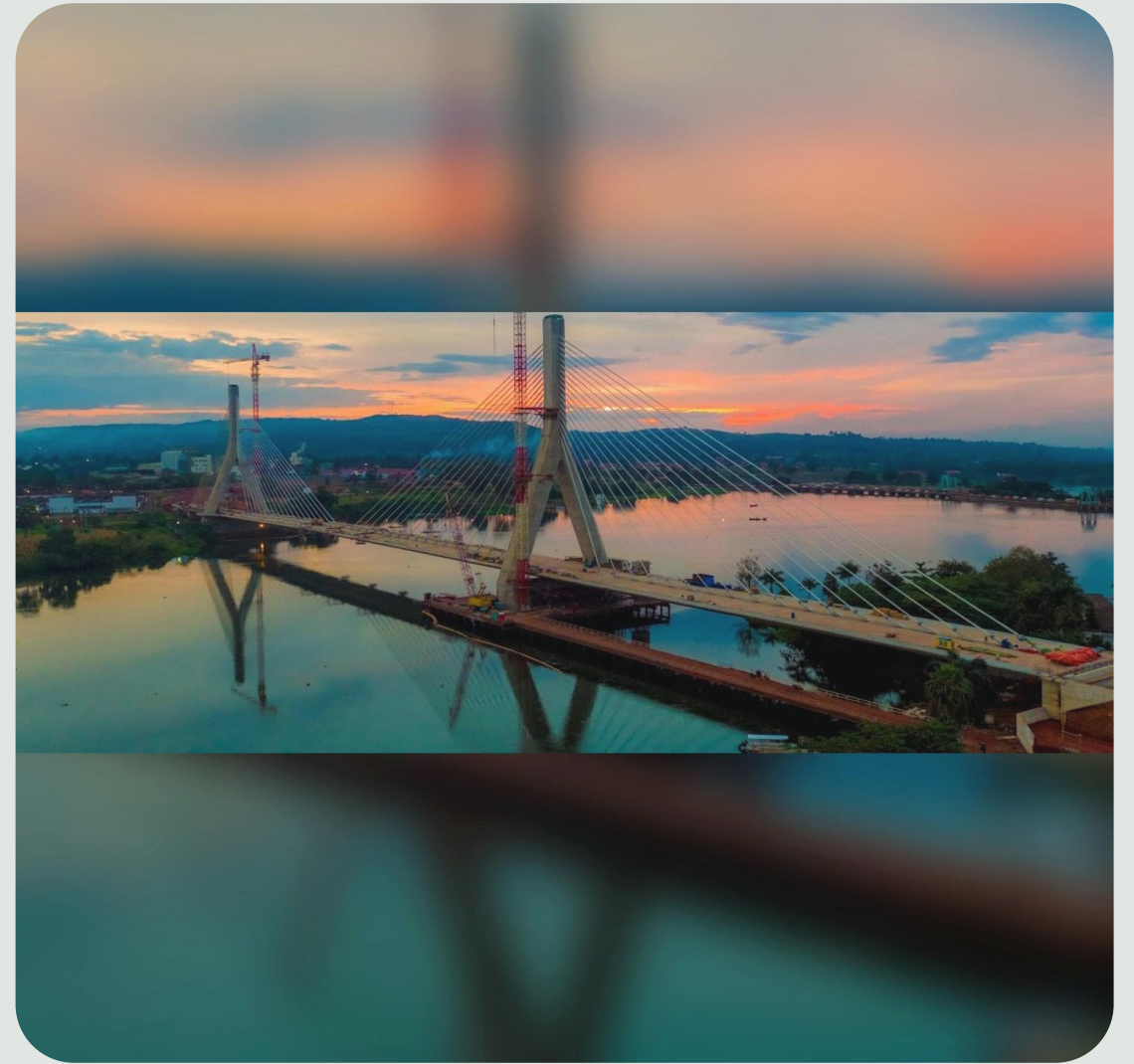


Example of General arrangement, the Source of the Nile Bridge (Source: DDC).

03

Design Review & Constructability

13 minutes · Ten lessons from a robust design



Review Everything, Then Have Someone Else Review It



Sensitivity analysis across every combination of bridge type and alignment confirmed the cable-stayed bridge, 500 m upstream of Nalubaale Dam.



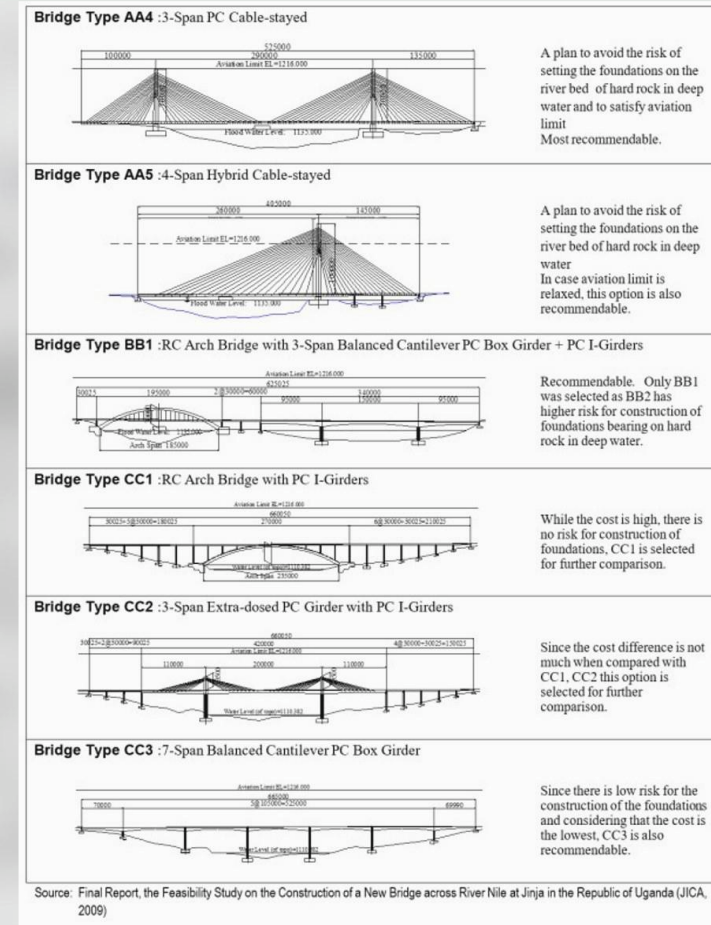
Major quantifiable benefits: savings in vehicle operating cost and travel time cost.



An Independent Design Check was procured on top of the detailed design, as an owner, you get a more rounded critique.



What follows: the design decisions the review process caught, changed, or confirmed.



Example of bridge-type alternatives assessed in review (Source: FS).

Design Speed: Hold the Alignment, Protect the Programme

80 to 120 km/hr



Feasibility assumed 80 km/hr; Detailed Design required 120 km/hr for the project road.



The change demanded more land, more acquisition, more compensation, more cost.

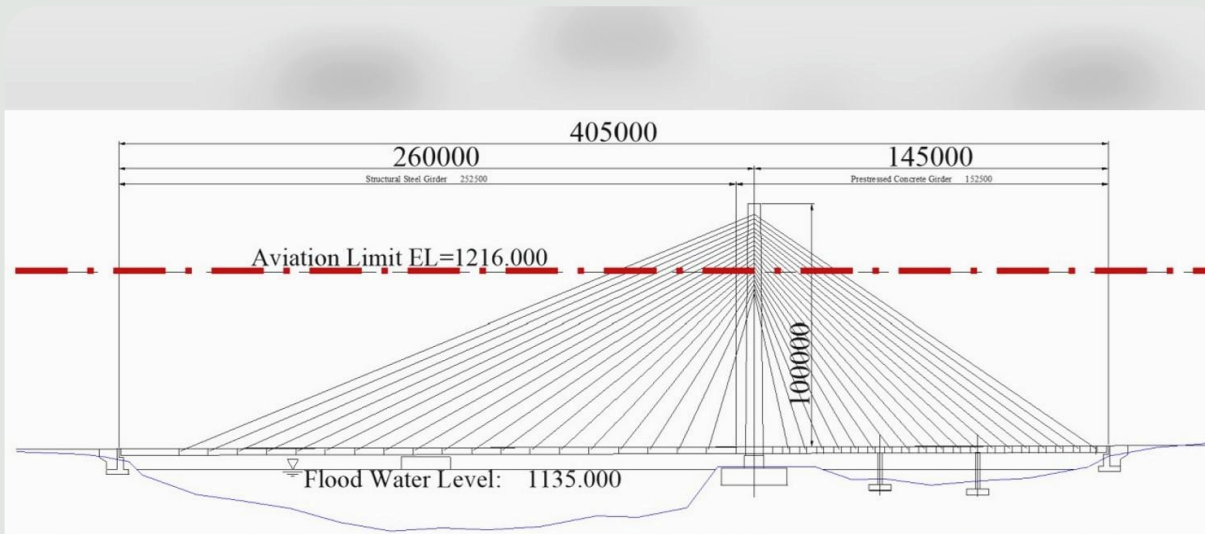


Decision: keep the original highway alignment, avoiding programme delay and escalating compensation cost while meeting the higher standard.

THE PRINCIPLE

A standards upgrade is only robust if the delivery plan absorbs it. Decide early, in writing, with the authority to do so, or the upgrade becomes the delay.

The Cheapest Pylon Would Have Pierced the Flight Path



CAA aerodrome surface vs. pylon height, the aviation limit that shaped the bridge.



CAA guidance on aerodrome infringement limits (inner horizontal surface).



A single-pylon option, cheapest in initial construction cost, required a pylon height in excess of the air-height restriction.



Alternatives were formally reviewed against the CAA inner aerodrome layer (IHS).



The 3-span prestressed concrete cable-stayed form won: it does NOT infringe the aviation limit.

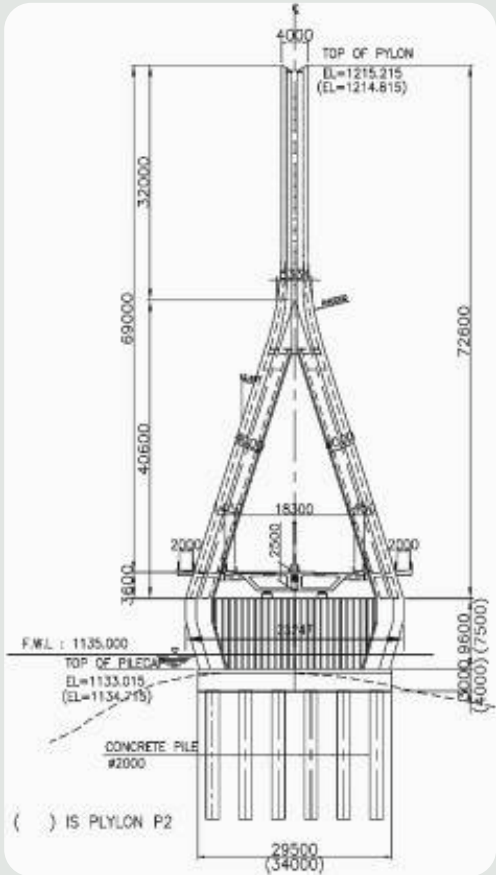
Regulators shape designs, engage them early, as CAA was, so constraints shape the design rather than wreck it.

One Plane of Cables Beat Two



Arrangement	Torsional rigidity	Maintenance & aesthetics	Verdict
Single plane • inverted-Y pylon	Box girder can exceed double-plane rigidity	Internal anchorages; clean soffit	SELECTED: stability + lower cost
Single plane • I-pylon	Comparable	Higher construction cost than Y	Rejected
Double plane • H-pylon	Lower with edge girders	External anchorages, more maintenance, poorer soffit	Rejected

Torsional studies showed a single-plane system with a box girder could be MORE rigid than a double-plane system with edge girders, the counter-intuitive result that review made defensible.



Example of Inverted-Y pylon (Source: DDC).



Back Span and Foundations: Let the Ground Decide

BACK SPAN, THREE OPTIONS ASSESSED

Heavily counterweighted main girder
SELECTED: best for maintenance, cost and aesthetics

Embedded girder
Rejected

Direct ground-anchored cables
Rejected

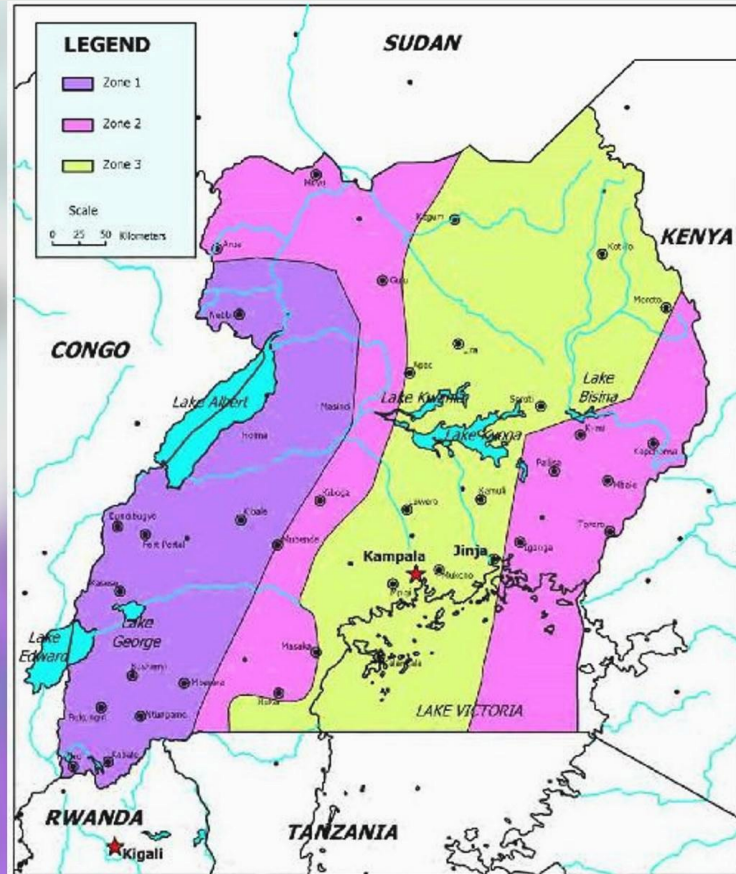
Given the Njeru-side topography, the back span did not necessarily require a bridge structure at all, the review asked the simpler question first.

P2 PYLON, FOUNDATION ON THE ISLAND

- Topographic survey found the island slope steeper than expected, the foundation needed enforcement.
- Pile diameter was increased from the Feasibility Study design after geotechnical and topographic review.
- Surveys are design tools, not formalities: the ground overrules the drawing.

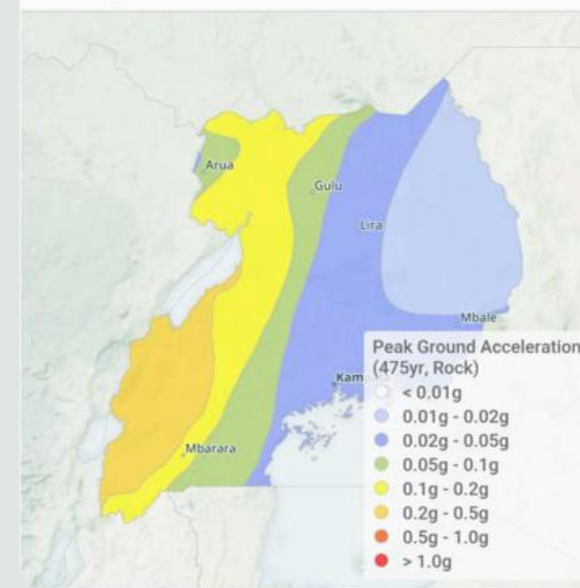
Seismic design: 3-D bar-element model set elastic response coefficients at 0.05 transverse / 0.10 longitudinal per Uganda's seismic code (US 319:2003).

Designed for the Ground It Stands On

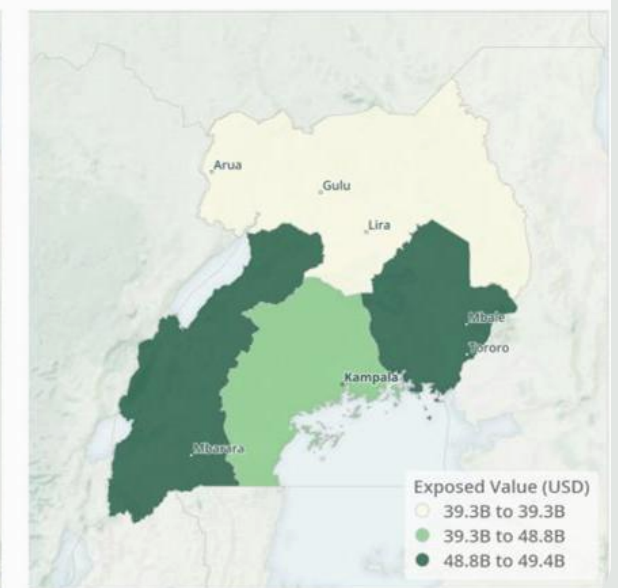


Uganda seismic zoning, US 319:2003 (UNBS).

EARTHQUAKE HAZARD



EXPOSED VALUE



Earthquake hazard and exposed value (Source: GEM, 2019).

0.05 transverse • 0.10 longitudinal elastic seismic response coefficients; vertical & torsional frequencies checked aerodynamic stability, transverse & longitudinal periods set earthquake forces.



Design for the Worst Wind You Can Find, Not the Nearest

18 m/s

Local max recorded

the comfortable local number

30.9 m/s

Outer record

adopted conservatively instead

43.9 m/s

120-yr instantaneous

from analysis of Entebbe data

35 m/s

basic design wind velocity

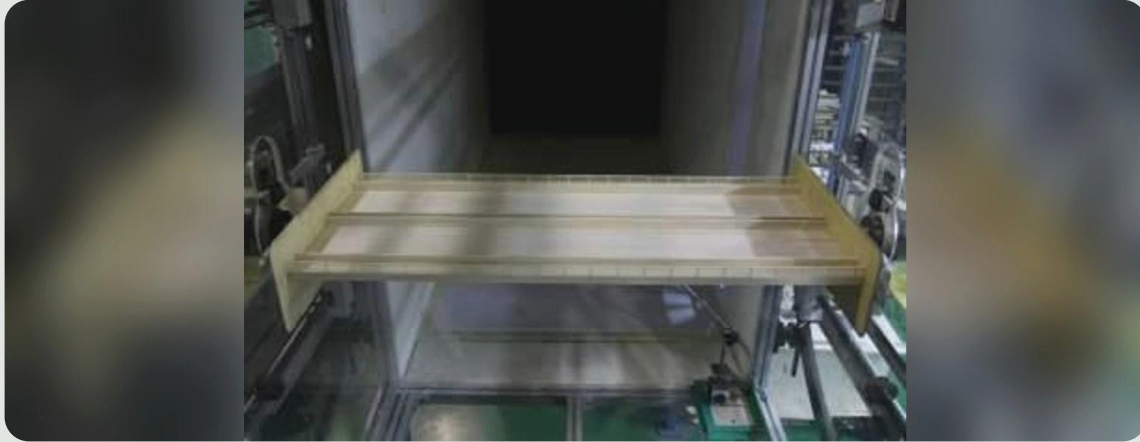
with a 20% safety factor applied

Aerodynamic stability depends on the deck cross-section. The 10-minute mean wind speed came to 29.3 m/s, every figure carried margin, on purpose.



Example of Wind-tunnel sectional and full-bridge models, smooth and turbulent flow (Source: DDC).

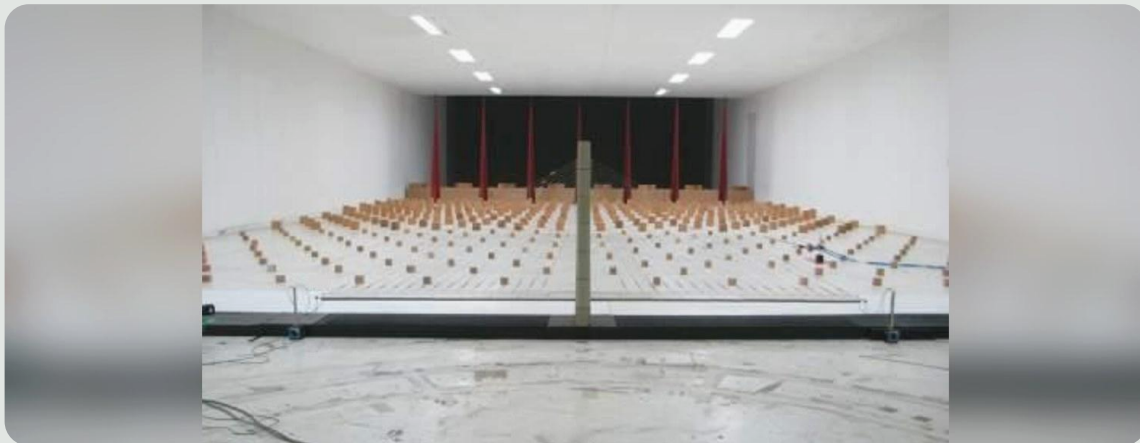
Proven in the Tunnel Before Built Over the Nile



Sectional model, flutter, galloping, vortex-induced vibration checks.



Half model under test conditions.



Full-bridge model, smooth flow.

RESULT

For smooth flow conditions, no wind-induced resonance, no vortex shedding, no flutter, was detected up to the design wind speeds.



Build in the Nile Without Polluting It



Silt & oil fences around jetties and neighbours' intakes.



Noise monitoring at the works.



Sedimentation & lime-neutralisation pond for concrete waste.

-  Beyond national environmental law compliance, the least-polluting construction methods were selected at design stage, jetties, oil and debris filters and fences.
-  Contingency plans were written before the first barge moved; on-site treatment handled construction waste from piling.
-  Protection extended to neighbours: factory and brewery water intakes were fenced and monitored throughout.

04

Construction Supervision & Delivery

11 minutes · What the site taught us



Working in the River, Keeping the River Clean



Example of Jetty construction into the water, ahead of cofferdam and piling.

TECHNOLOGIES AND METHODOLOGIES USED IN THE CONSTRUCTION - WATER



Installation of cofferdam



Water displacement in cofferdam



Stabilization in cofferdam



Pile excavation in cofferdam



Pile's Reinforcement cage installation



Pile's concrete casting

Example of Cofferdam sequence: installation, displacement, stabilisation, piling.

Sequence mattered: jetties first, then cofferdams, then piling for the pylons, construction in water with minimal pollution or contamination, exactly as the environmental design intended.



Six Months time agained back during superstructure works

6 months

lost to unforeseen 'hard rock' challenges



The recovery came in the superstructure: a steep learning curve on the balanced-cantilever deck segments.

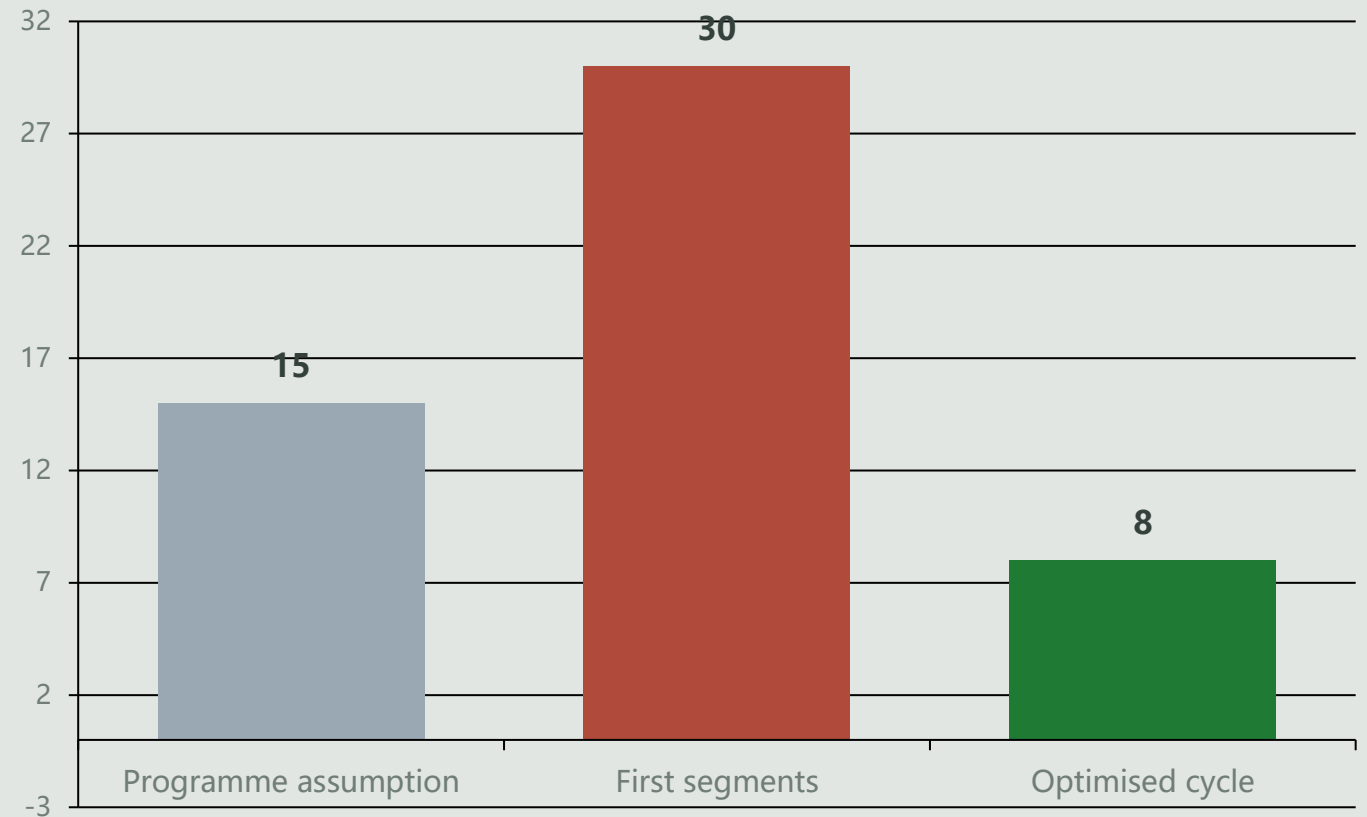


First segments took ~30 days against a 15-day programme; the optimised cycle closed at ~8 days.



Night work became inevitable, and the cycles got faster still.

Deck segment cycle time (days)





Materials: a Tedious, Painstaking Battle Worth Fighting



Aggregate and sand sources depleted mid-project; gradations drifted, some too fine, some too coarse, some laced with deleterious material.



Blending was required just to meet the gradation envelopes for the first concrete classes, without expensive rejections, especially at trials.

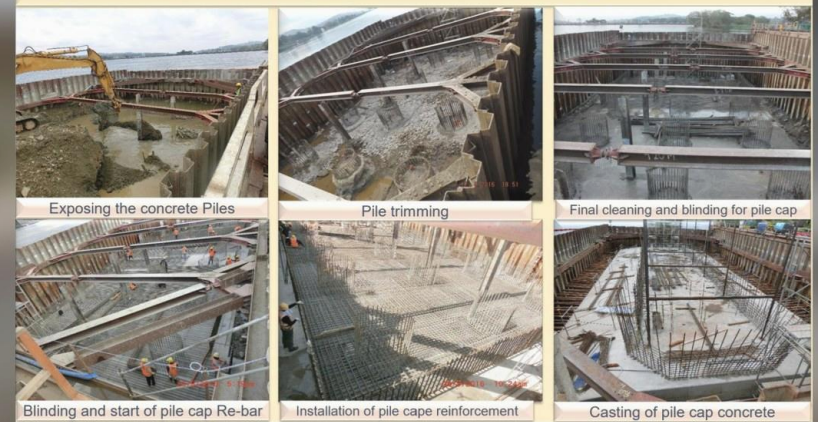


Cement, water and every concrete class needed approvals, quality compliance was a process, not an event.



Mass concrete casting in large volumes demanded its own thermal and logistical planning.

TECHNOLOGIES AND METHODOLOGIES USED IN THE CONSTRUCTION- WATER



Example of Pile-cap works: exposing piles, trimming, re-bar, casting.

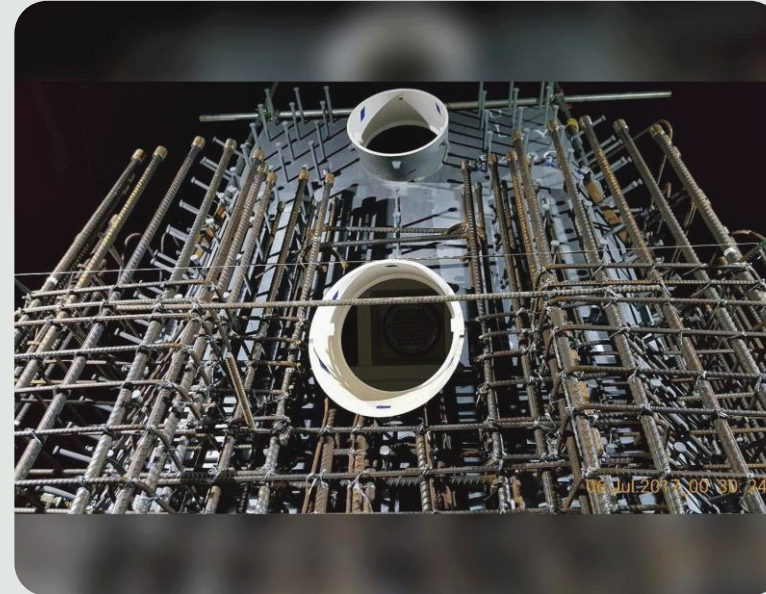


Example of Deck reinforcement and concrete crews at work.

Raising the Pylons: Forms, Couplers, and Watched Concrete



Example of Pylon legs under climbing formwork, tensile forces .



Example of Mechanical couplers simplifying interstage reinforcement.

- Traveling and under-climbing forms carried the inverted-Y geometry upward.
- Mechanical couplers made interstage pylon reinforcement practical and fast.
- Pylon leg concrete was watched against the crack risk the Independent Check had flagged, strict compliance, every lift.

Balanced Cantilever: Geometry Is Won at Night



Example of Form travelers advancing the deck from the pylon.



Example of night works



Deck concrete demanded coordinated pumping, placement, compaction and finish, look mattered as much as strength on a signature bridge.



Horizontal and vertical alignment control ran continuously while catching up on programme, geometry checks governed every segment pair.

The Structural health monitoring sensors



When I was brought on board, a proposal existed to remove the strain meters, inclinometers and survey target prisms from the design.



In my independent review I reached teams who had instrumented similar structures abroad Europe, who gave weeks of free remote support.



We developed a counter-proposal: retain the sensors, and add inclinometers, strain gauges and DGPS points across the structure.



I drafted a recommendation report to the Project Manager and Management, the proposal was accepted.



Rion-Antirion Bridge, Greece,



Normandie Bridge, France, the systems working, decades on.

Benchmarked on best practices



Megami Bridge (Nagasaki), MLIT Kanto offices, Chiba WIM site.



The European visits led to an employer's invitation, and then a full benchmarking visit to Japan against the Megami cable-stayed bridge.



Outcome: full structural health monitoring adoption, plus an overhead secondary lightning-protection system and a weigh-in-motion system.

MEGAMI BENCHMARK • LIGHTNING

> 5 kA surge carried safely to natural earthing ground, protecting everything within a **30 m spherical radius** per 2 m air terminal, with no damage to protected equipment.

The Sensors Watching the Bridge, Around the Clock



Strain gauges

girder & pylon strain



Load cells

cable tensions



Inclinometers

pylon tilt



Kumonos

crack mapping



Seismometer

earth tremors



Weather station

wind · temp · humidity



Joint sensors

expansion movement



RTK GPS

deflections



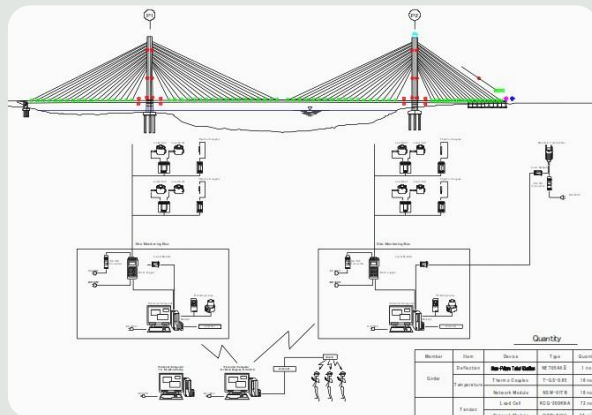
WIM

vehicle axle loads

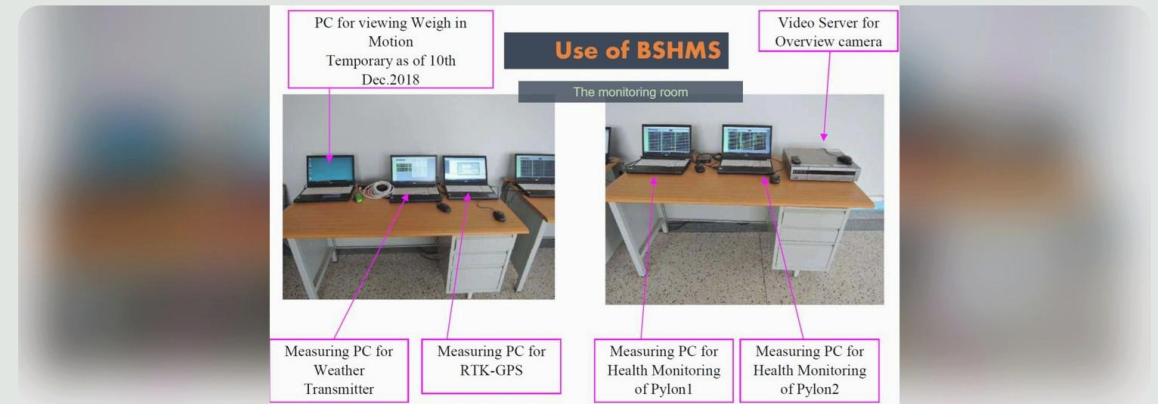


Cameras

vehicle shape & plates



A typical BSHM system architecture



The monitoring room, WIM, RTK-GPS, weather and pylon-health stations.

Installed, Struck by Lightning, Protected, Load-Tested



Examples of Strain gauges.



Examples of Inclinometers.



Example of Weigh-in-motion gantry,.



Example of weather station on the structures



Lightning strikes hit sensors after installation, the secondary protection system and replacements proved their worth immediately.



Full bridge load tests closed out the instrumentation story: measured behaviour matched design.

Opened 17 October

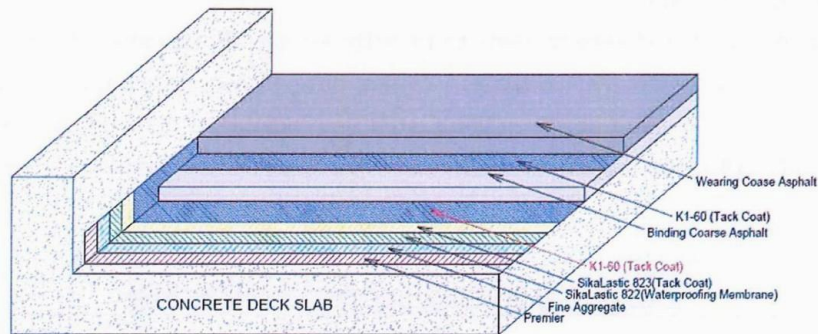


Photo of the poor bonding



Replacement of asphalt on bridge deck

Countermeasure for the bonding defect



The countermeasure, rebuilt bonding layers over the deck slab.



The bridge was commissioned and opened to traffic, 2018.



By opening, some defects appeared on the import lane at the entry and exit, the asphalt was not achieving the desired bond to the deck.



The bonding system was re-engineered, tack coats, binding course and waterproofing rebuilt as designed in the countermeasure.

A signature project earns credibility not by having no defects, but by finding, admitting and fixing them fast, on the record.

05

Role of the Employer's Representative

4 minutes





Delivery Is Finishing. Success Is Celebration.

You are the first level of acceptance, you define what value and success look like, because you interface with funders (GoU, GoJ) and every internal and external stakeholder: public, parastatals, contractor, consultant, suppliers, regulators.

0

fatal accidents

amidst all the risk in the nature of the works

0

child abuse / defilement cases

registered on the project



HIV VCT success

voluntary counselling & testing programme



community uplift

employment, supplies, terminal benefits for local workers

Community sensitization succeeded, and livelihoods measurably improved. These are success metrics as real as the concrete, and they are the employer's representative's metrics to own.

Three Seats You Occupy at Once



Definer of success

First level of acceptance, you decide what value looks like, for funders, government and public alike, before anyone else signs.



Resolver before disputes

Most equipped to settle claims before they occur, insight into employer, project and site management, with separate but direct obligations to both Contractor and Consultant.



The face of Government

To everyone, contractor, consultant, suppliers, workers, the public, even GoU agencies, you ARE the government on site: social, financial and technical questions all land on you. And in many ways, they are right.

06

Contract Administration & Governance

4 minutes





Five Governance Levers That Decided the Outcome



Delivery mode & contract type

D-B-B allowed re-measured quantities and rate revision. Pick the mechanism that fits the risk.



Employer's team on site, full time

De-escalated strikes in hours, with management 2 to 3 hours away. Days, not disputes.



Team selection & replacements

Deploy the people promised, replacements equal or better. Expat-local pairing built capacity.



3-member Dispute Board

A single-member DB strained relations through DNP/DLP and close-out. Three carry less risk.



Disburse in the facility's currency

Match the disbursement currency to the facility. Stop FX losses eating the works.

The Team Behind the Bridge, and Who It Left Behind

9

Client staff on site, full time

Including, the Contract/Project Manager, Project Engineer, Clerk of Works, graduate trainee + co-opted experts

33

Consultant staff • 67% Ugandan

11 experts mirrored 1:2 by local counterparts

760

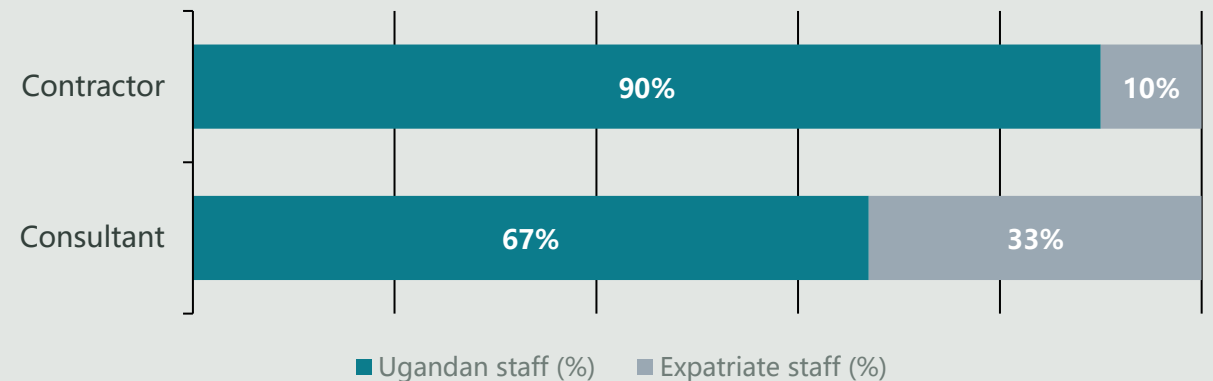
Contractor staff • 90% Ugandan

80 expatriates alongside 680 Ugandans



Examples of workers

Knowledge transfer by design: local majority at every tier



07

My Bottom Line

7 minutes · Why this bridge beat the odds



Across Africa, Delay Is Not the Exception, It Is the Pattern

7 in 10

of 480 public projects ran late

across the continent, where data exists

+73%

average overrun vs. planned duration

for the projects that ran late

60%

of delay drivers pre-date construction

planted in feasibility, scope & financial planning

Put more bluntly: **roughly 80% of African infrastructure projects never get past feasibility at all.**

And in Uganda, the Delays Trace Back to Us, the Client Side

>90%

**of Uganda's road projects
finish late**

measured across the national portfolio

~80%

of those delays are client-side

planning · land · approvals · payment

28 / 67

road projects delayed

13 abandoned or suspended

Shs 500bn

in arrears

incl. Shs 74bn pure interest, money
that built nothing

Not contractors. Not weather. Us.

27 projects suspended in a single year, and a freeze on new road projects. This is the environment every seat in this room prices, plans and delivers in.

This Bridge Beat Those Odds, and Not by Luck



Options tested & retested

Two feasibility studies and a pre-investment study before a single pile was driven.



The independent check, paid for and listened to

The Abutment 1 / pylon-leg crack risk was caught on paper, never in concrete.



A full-time employer's team on site

The early-warning system that settled in days what elsewhere ripens into years of dispute.



Timely decisions by empowered people

Design speed, pylon form, wind data, decided in time, by people with authority to decide.

That is the role of the employer's own representative: the difference between delivery, which is merely finishing, and success, which is a bridge the funders, the government, the contractor and the public all celebrate.

What Is In-House Can Be Fixed In-House



Spend on preparation

60% of delay drivers are born at the front end. This bridge ran three studies before a single pile, that is where your best engineers belong.



Buy the independent check, and listen to it

Ours caught a potentially catastrophic crack risk on paper, against a portfolio of 28/67 delayed projects and Shs 500bn in arrears.



Empower your representative in writing

Delegated authority over approvals, scope, payments and land, plus a direct line to the accounting officer. Days, not years.

Not chiefly about more money, but empowered public engineers making timely, defensible decisions, and the bills those decisions certify being paid on time.

Understanding the Employer Is the Half That Decides Survival



Know who can instruct you, and within what limits

Ask for the delegation matrix at kick-off. Under FIDIC, an instruction from the wrong person is a claim risk you carry.



Treat the representative as your risk interface, not your adversary

A well-structured submission and an early warning reached a decision-maker in days. Defensible paper prospered.



Keep records as if an arbitrator will read them

The contested determinations will be, and the better contemporaneous records usually prevail.

The strongest contractors in difficult environments work transparently with the employer's people, fewer disputes, protected cash flow, and the next contract.

Design Review Is Delay Prevention, Not Paperwork



Your value is the thinking, not the watching

Five bridge forms, the CAA pylon limit, Entebbe's wind record, the single-plane torsional case, design changes are Uganda's most severe delay factor.



Wear your two hats honestly

Act for the Employer, determine claims fairly (FIDIC 1999 / 2017). Agree the approval protocol before the first claim, a fettered engineer is a jammed contract.



Deploy who you promised, and build capacity as you go

Replacements equal or better; stay within written delegation; the engineers you mentor are the project's lasting foundation.

The best consultant is a governance partner to the client, that is how projects move from feasibility to execution to service delivery.

This Bridge Had More Parents Than Three



FUNDERS

The cheapest risk mitigation you will ever buy: a well-staffed employer's representative function and an independent design check. Insist on both as financing conditions, and disburse in the facility's currency.



REGULATORS

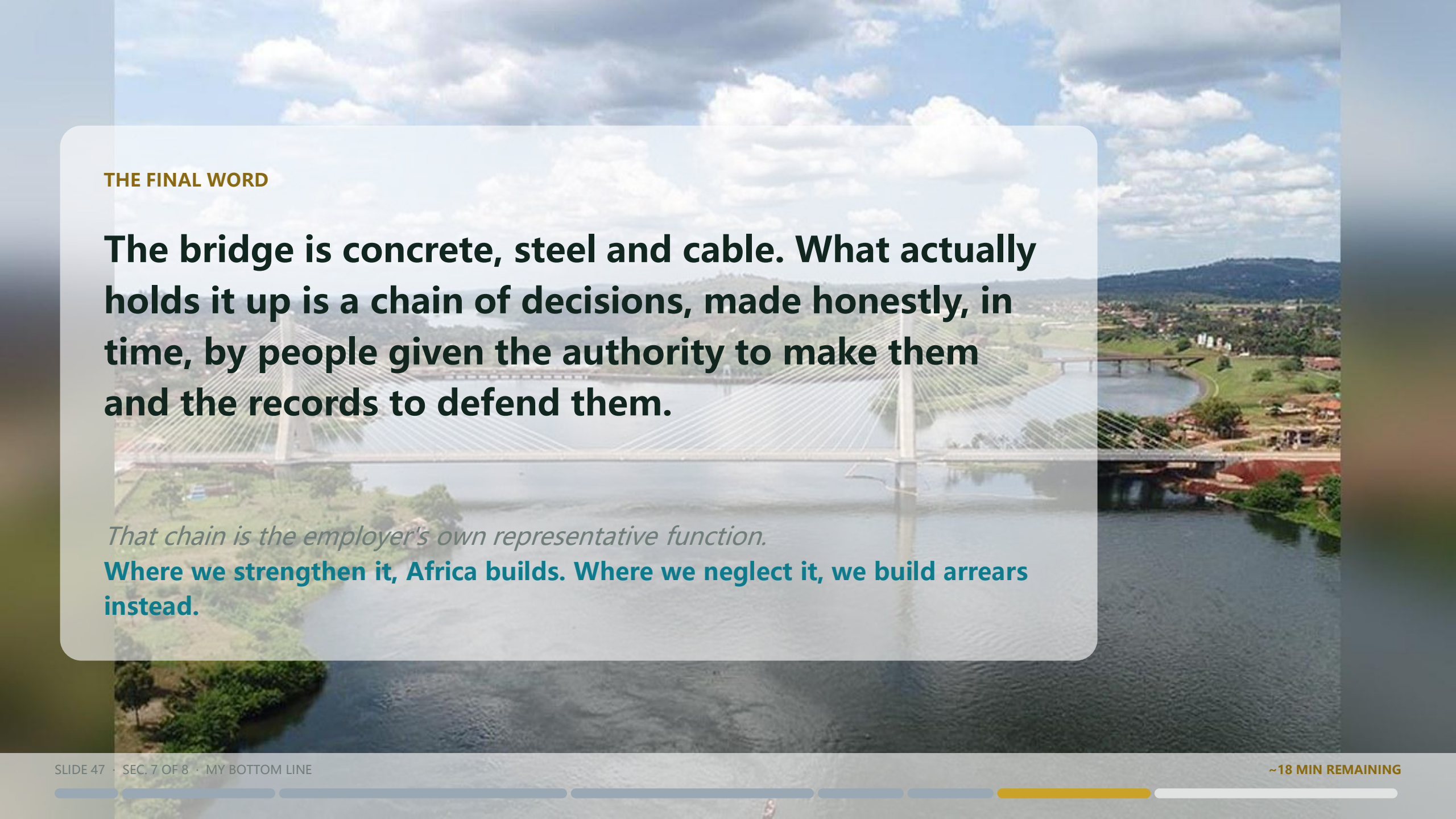
Engage early, as the CAA did, its height restriction literally shaped the pylon. Constraints raised early shape designs; raised late, they wreck them.



THE PUBLIC

The bridge is yours. Ask who the employer's representative is on the next project in your district, that person is where your taxes turn into either a landmark or an arrear.

The World Bank financed the pre-investment study; Japan financed feasibility, construction and supervision; steering committees and public consultation carried the community from inception to design.



THE FINAL WORD

The bridge is concrete, steel and cable. What actually holds it up is a chain of decisions, made honestly, in time, by people given the authority to make them and the records to defend them.

That chain is the employer's own representative function.

Where we strengthen it, Africa builds. Where we neglect it, we build arrears instead.



Questions & Discussion

Thank you, I look forward to the conversation.

Arthur Mijumbi · Uganda