A Better Bridge Design For Road and Marine Traffic

Tabora Boys' Secondary School

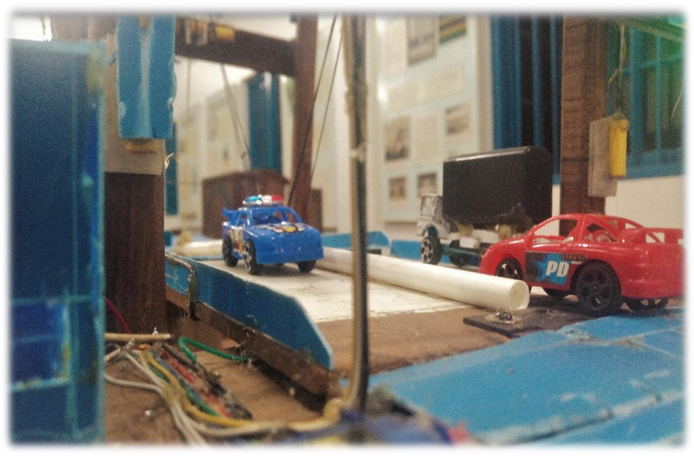
Davis Valentine Marandu and Bonaventure Barnabas Msolini

Introduction

Well as big cities grow in Tanzania, the population rises, this means more people will be moving from place to place at one instant, in Dar es salaam, this has recently been a major issue as it has greatly increased road traffic, now currently marine traffic is almost unnoticeable but one can expect a great rise in sea traffic in the near future as Tanzania spins into an industrialized economy.

The project was established with goals on designing a better bridge system across water channels one that fully supports marine traffic flow (inclusive of big ships) and fully support on road traffic (including large trucks) across a water channel (say a big river).

This is to conquer traffic flexibility which becomes very crucial as traffic congestion intensifies. In simple words, our goal is to design a bridge that opens its leaves (the road pathways) to allow flow of boats and ships and then on closing them allows flow of cars and trucks.



In the project, the major requirements are;

- Plastic rulers – as a source of plastic, a core molding material.
- Used up pens – the bodies of which will make plastic cylinders for the sliding mechanism of the super-structure and also used in making plastic pulleys.
- DC motors – The main actuators that will power all mechanical parts.
- Wood – A major building material used to create the large physical bridge parts.
- Broken Umbrellas – as a source of strong metal rods.
- Super-Glue – as a main heavy-duty adhesive for binding wood and plastic parts.
- Laboratory Optical pins – used as axles in fixing plastic pulleys.
- Bolts and Nuts – to fix wooden bridge parts together firmly (ones that are too sensitive to hammering).
- Iron nails – to bind bulk wooden sections of the bridge together firmly (1 and 2-inch).
- Nylon Thread – used as string in making a pulley-and-thread pair.
- An Arduino Microcontroller – an embedded computer to control and coordinate all electronics.
- A Standard Computer (PC) – to program and develop software for the microcontroller.
- Miniature electronics - LED lights, resistors, motor-driver, transistors, an entire arsenal of gribbles.
- Plastic PVC pipes – a core source of modelling material, Poly-Vinyl Plastic is used to model all the small props and assets that add functionality and realism to the bridge structure.
- Mini Servo Motor– to power automatic traffic barricade units.

Method

In this project, our methods were experimental, we got first hand-data directly from equipment and instruments of measurement like meter-scales and electronic meters in hand with online literatures where required

Procedure

i. Established a Concept design of the bridge model.

We sketched a concept model on paper for the bridge model we had in mind and settled on an original design.

We modelled the sketch in computer using Blender- a production ready 3d creation software, and finished with a fine-looking 3d model.

ii. Blocked and constructed the base, terminal sides and a super-structure

iii. Added pulleys, nylon threads and glued everything into a working set.

iv. Incorporated electronic systems

v. Added a control interface

vi. Added a sound system for alert alarms and caution lights

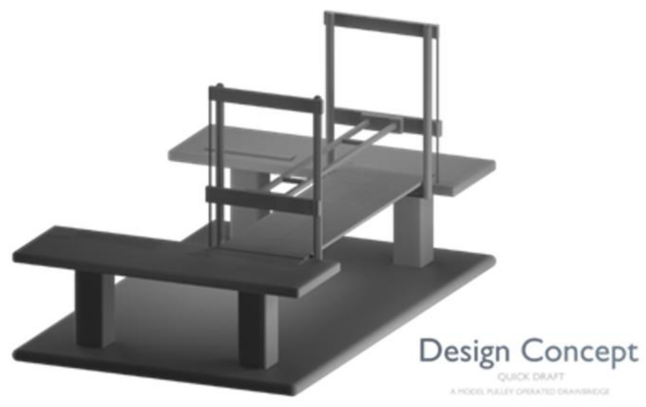


Image: A finished Original concept Design of the Bridge at its early stages.

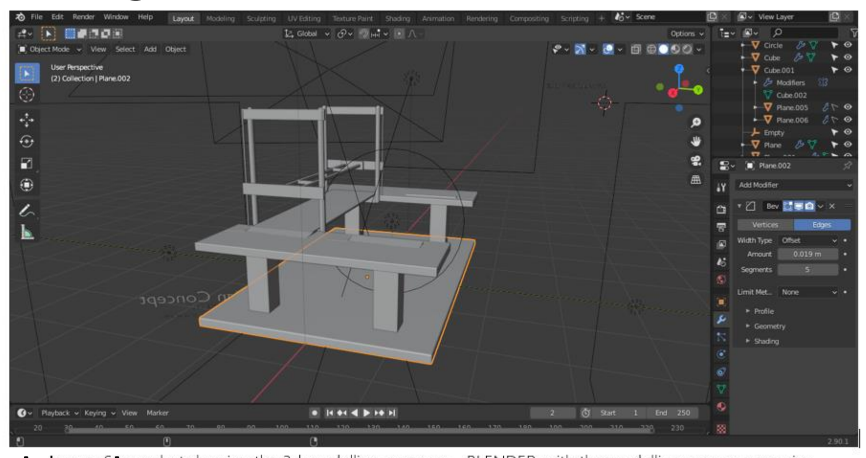


Image: Screenshot showing the 3d modelling program – BLENDER, with the modelling process on-going.

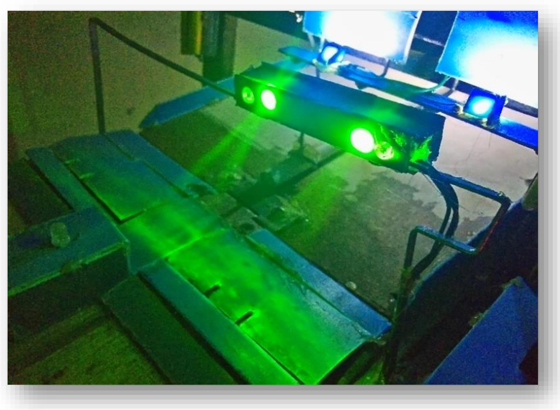
The different components of the bridge system are controlled by a microcontroller chip; The Arduino Nano, the chip has been programmed to operate in the following manner;

On power-up, the chip's bootloader initiates program execution following pre-defined instructions according to our code sketch in performing different operations;

Results

We have been able to achieve very good results with the physics of the bridge,

The bridge's electrical system has an efficiency of up to 78%, which is a good value given the crudeness of the techniques and tools employed in its fabrication. Here the limits arise due to friction between mechanical parts as they move past each other and also due to errors in measurements as we used standard school rulers instead of electronic calipers which better suit the task.



1. The traffic lights are set to red to stop flow of road traffic as it is not safe to continue.

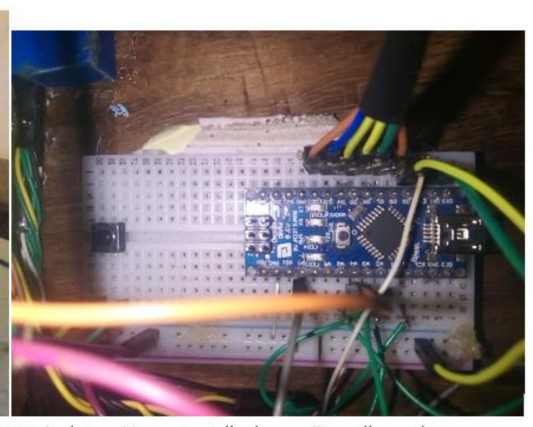


Image: winches installed and strings attached. Image: Arduino Nano installed on a Breadboard.

Model Scaling: 1 : 83 centimeters.

PROPERTY	MODEL	ACTUAL BRIDGE
Overall length	70cm	58.1m
Overall breadth	24cm	20m
Overall height above MSL	44cm	36.5m
Road height above MSL	11cm	9.1m
Number of lanes	4, dual carriageway	4, dual carriageway
Lane width	3.8cm	3.2m
Lateral clearing for marine transit.	18cm	15m
Vertical clearing for marine transit	30cm	25m
Side lanes for pedestrians & /cyclists	absent	Present
Toll booths	present	Government Defined
Warning and safety lighting	present	present
Overhead road lights	present	present
Traffic Control lights	present	present
Cabling	strings	Steel HT cables
Control and monitoring	AVR microcontroller on the Arduino Dev. platform	Professional and Certified technician/personnel
Protection Components for electronics	¾ watt standard 220Ω resistors, Mains isolation by a consumer-grade power supply adapter	High-precision protection Circuitry

COMPARISON CRITERIA	OUR BRIDGE DESIGN	THE KIGAMBONI BRIDGE
Traffic flexibility and maneuverability	Has 4 very tight lanes for on-road traffic due to relatively thinner lanes(3.2m wide) it is unfit for articulated vehicles(Semi-trailers) when near an immediate turn.	Carries 6 lanes dual carriageway, allowing for 3 independent streams of vehicles in either direction.
Technical complexity	It's sliding super-structure and raising leaves greatly increases technical complexity in both construction and operation.	Bulk physical structure of rigid concrete and metal with no moving parts except for suspension cabling.
Construction costs	Due to it's smaller size, the design is relatively cheaper estimated to cost about 20mil USD using material prices on the international market	The NSSF gave a cost of about 135mil USD for full construction of the bridge
Maintenance costs		
Size	The bridge is 60m long, about half the length of a football field	The bridge is 680m-long which is about 10x the size of our bridge
Inter-traffic flexibility	Fully supports flow of any kind of road or marine traffic.	Fully supports road traffic while sea-traffic is limited to small vessels(boats) that can pass under it.
Suitable locale	Tailored for a compact and denser locale where space economy is critical like in crowded cities.	size and structure requires an open and free geographical location to completely embrace it's majesty.

Conclusions

From the nature of our results being very positive, we can boldly conclude that, we have been able to design a bridge that is better than the existing ones and stands a chance among other bridges in Tanzania such as our case: The J.K Nyerere Bridge at Kigamboni, The Mkappa Bridge or The Kigongo-Busisi in Mwanza..

Acknowledgments

We give gratitude to God almighty, our parents, guardians, friends, and benefactors and most especially to all competitors who have made us think big. It has always been great pleasure for us to be a part of this great initiative and we are looking forward to doing more great things in the course of our science careers