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# Numerical modelling of deployable bridge using solid works.

# Modelado numérico de puente desplegable mediante obras sólidas.

Ayesha Tanha[1], Abdul Khalike KR[1], Hasna PH[1], Christy Francis Lonth[2]

[1]Student, Department of Civil Engineering, Toc H Institute of Science & Technology, Kerala,

[2]Asistant. Professor, Department of Civil Engineering, Toc H Institute of Science & Technology, Kerala

Corresponding author's email: ayeshatanha00118@gmail.com (Ayesha Tanha)

## ABSTRACT

The deployable structure is one of the upcoming techniques because of the infrastructure's quick development, which gives rise to a wide range of structural designs. A deployable structure is one that can drastically alter its size by changing shape. There are various potential uses for deployable structures, from temporary shelters and amenities to movable, semi-permanent buildings and space station components. Their primary benefits include modest storage and transit volumes and a quick and simple erecting process. This is being done for its ease of construction and capacity to adapt to the environment. SOLIDWORKS Software, a program that may be utilized for structural analysis and design of the pedestrian deployable bridge, is employed in this process.

Keywords: Deployable Structure, Relocatable, Evacuation, Semi-permanent, Adaptability

## RESUMEN

La estructura desplegable es una de las técnicas de próxima aparición debido al rápido desarrollo de la infraestructura, que da lugar a una amplia gama de diseños estructurales. Una estructura desplegable es aquella que puede alterar drásticamente su tamaño cambiando de forma. Hay varios usos potenciales para las estructuras desplegables, desde refugios temporales y servicios hasta edificios móviles y semipermanentes y componentes de estaciones espaciales. Sus principales beneficios incluyen volúmenes modestos de almacenamiento y tránsito y un proceso de montaje rápido y sencillo. Esto se hace por su facilidad de construcción y capacidad de adaptación al entorno. En este proceso se emplea el software SOLIDWORKS, un programa que puede utilizarse para el análisis estructural y el diseño del puente peatonal desplegable.

Palabras clave: Estructura desplegable, Reubicable, Evacuación, Semipermanente, Adaptabilidad

## INTRODUCTION

Emergency departure the use of deployable scissors-style mechanism ridges is a novel approach to the problems of transportation and emergency evacuation. These bridges are made to be quickly and easily deployed, providing quick access to a secure location. They can be employed in a range of circumstances, including emergency evacuations, man-made calamities, and natural disasters. The bridges are perfect for emergencies because they are lightweight and portable. They can also be used for a wide range of other purposes, including enabling access to distant locations and serving as temporary bridges in places where conventional bridges are not present. In this essay, we'll talk about modelling the deployable bridge with SOLIDWORKS.

Ario (2020) introduced an equilibrium mechanics approach and a finite element model for analyzing a scissors structure that exhibits structural instability due to zero bending stiffness in its pivots. The pivotal connections at the center of each structural unit, characteristic of scissors structures, enable the transfer of displacement between the units. The angular stiffness of each unit must be considered independently. A scissor bridge, composed of multiple scissors units, can be classified as a periodic structure, also known as a cell structure, with unit cells resembling honeycomb structures. To prevent structural instability and allow for flexible adjustments in support and load conditions, finite element methods (FEM) utilize elements with numerous degrees of freedom. Each scissor unit consists primarily of four individual elements, which need to be combined to represent a coordinate system. The FEM model of the scissor unit comprises a configuration of four degrees of freedom, including the extended nodal force vector and the displacement vector at each nodal point within the unit structure. By leveraging the periodicity of the scissor structure, a standardized element can be constructed for a single scissor unit (Ario, 2020).

According to Yan Hua Choy (2020), military bridges can be categorized into two types: assault bridges and tactical bridges. Assault bridges facilitate rapid gap crossing, while tactical bridges are used for longer gaps. The system requires two operators for operation. The crew can deploy the bridge within five minutes, while being protected by armor, from one end of the gap and retrieve it from both ends within 10 minutes. These bridges can be supported on unprepared and uneven ground without the need for foundation works. Open deck bridge designs, which have a lower dead load, are particularly favored for railway bridges due to their lower maintenance costs compared to ballasted deck bridges. Deadweight reduction can be achieved by replacing the existing concrete deck and guardrail system with a lightweight deck and guardrail. One such lightweight deck system is the open steel grid deck, consisting of fabricated elements that are either welded or bolted to the bridge superstructure. The emergency bridge's extension and retraction mechanisms are designed based on the principles of the Nuremberg scissors theory, which is a planar mechanism comprising interconnected links and pins forming a retractable and expandable scissors-like structure. The advantage of the scissors linkage is its ability to be deployed or collapsed with minimal force. The Nuremberg scissors represent a collection of rigid bodies linked together by kinematic constraints (Yan Hua Choy, 2020).

## MODELLING OF SCISSORS-TYPE BRIDGE USING SOLIDWORKS

Engineers and designers frequently use SolidWorks, a 3D computer-aided design (CAD) programme, to construct, simulate, and analyze 3D models. utilised in many different sectors to provide high-quality transportation products.

SolidWorks is an easy-to-use program that allows users to create 3D models, drawings, and assemblies quickly and accurately. It is designed to help users create complex designs in less time, with a high level of accuracy and detail.

## STRUCTURAL COMPONENTS

According to Fig 1. Four links make up a scissor link cross set, together with a deck, cross shaft, deck shaft, and pin.. The structure is composed of a total of 56 components. The plan is made with SolidWorks. The link's size is chosen to ensure that it has the best possible weight and strength. These links, which are regarded as a key part of the framework, support 40% of the bridge's overall weight. The primary structure through which traffic on the scissor bridge must pass is the deck. The interlocking technique is used to create the deck's pattern. The deck can be joined in various configurations to increase the length. The folding mechanism for the bridge can return to the folded state thanks to the interlocking design's additional benefit. The cross shaft maintains the links' connection and permits rotational movement. This cross shaft has been created to resemble a typical circular rod. The deck shaft serves a similar function to the cross shaft, with the exception that when the structure is opened to the horizontal position, the deck can rest on a flat surface in the center of the shaft. The pin's straightforward function in the structure is to keep the links in place and to give them angular movement or rotation. The pin functions similarly to a bearing, in other terms.This pin needs to be accompanied by sets of bearings, though, as it is a component of the links in the real-scale scissor bridge.

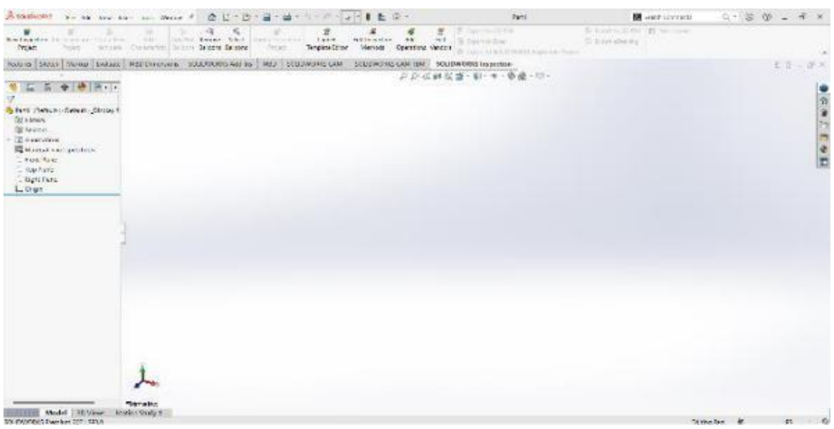


Fig No. 1 Interface of SOLIDWORKSSoftware

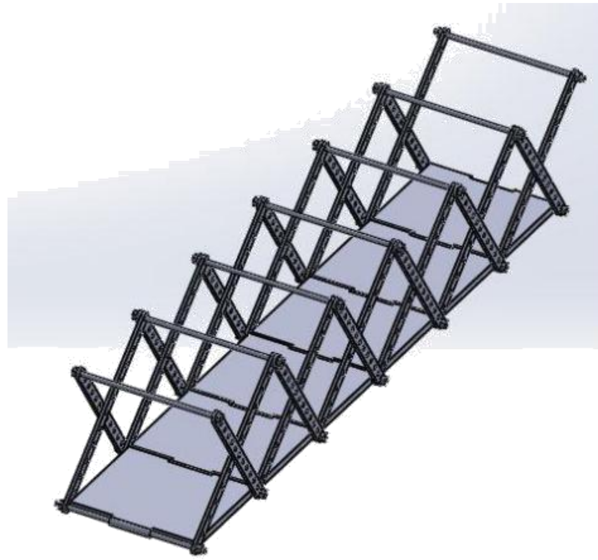


Fig No. 1 Model of the bridge

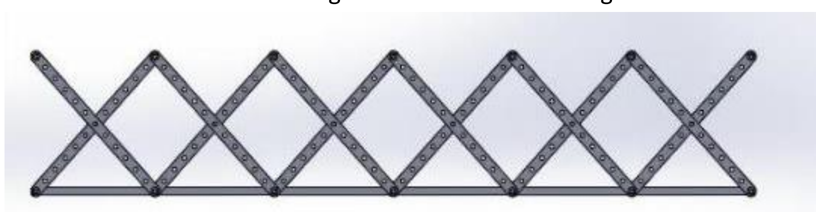


Fig No. 2 Side view

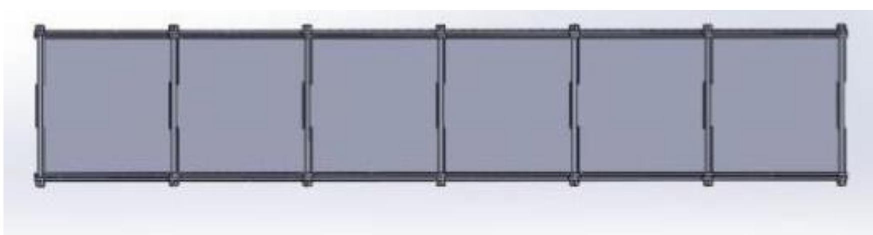
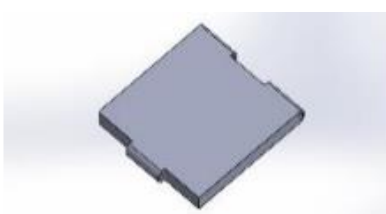
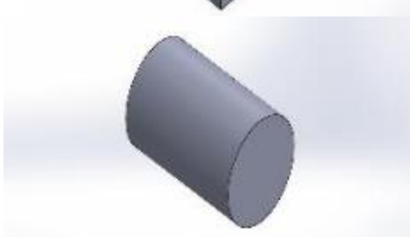


Fig No. 3 Top View

( a ) 

( b ) 


(c)

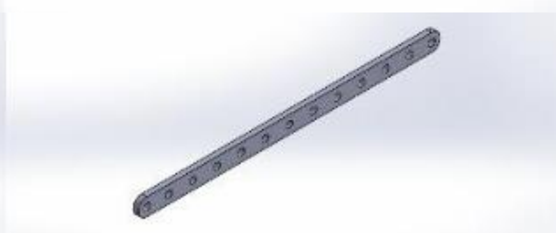

( d )

Fig No. 4 Components of the bridge (a)Deck (b)Shaft (c) pin (d) Link

Table 1. Dimensions of the Components

| COMPONENT | DIMENSIONS |
|---|---|
| LINK | Length:3312mm, Width: 150mm, Thickness: 50mm, Hole Diameter: 80mm |
| DECK | Length:2340mm, Width:2200mm, Thickness: 60mm |
| CROSS SHAFT | Length:2560mm, Diameter:78mm |
| DECK SHAFT | Length: 2560mm, Diameter: 78mm, Length of flat surface:2260mm |
| PIN | Diameter: 78mm, Length:120mm |

Fig1: Modelling of The Bridgeflow

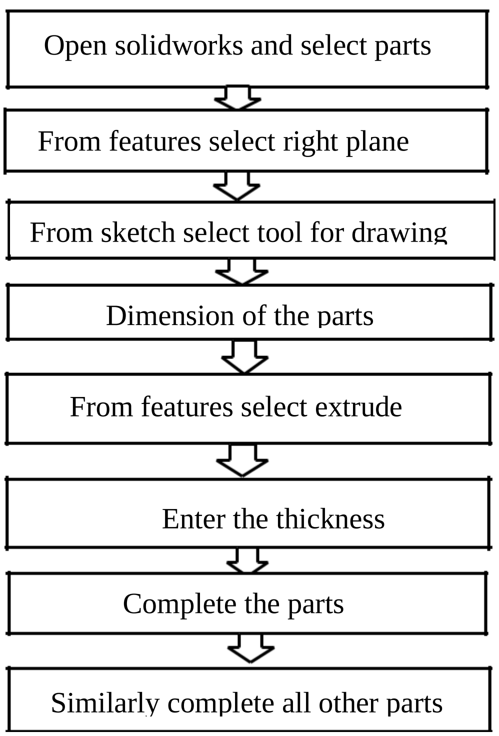
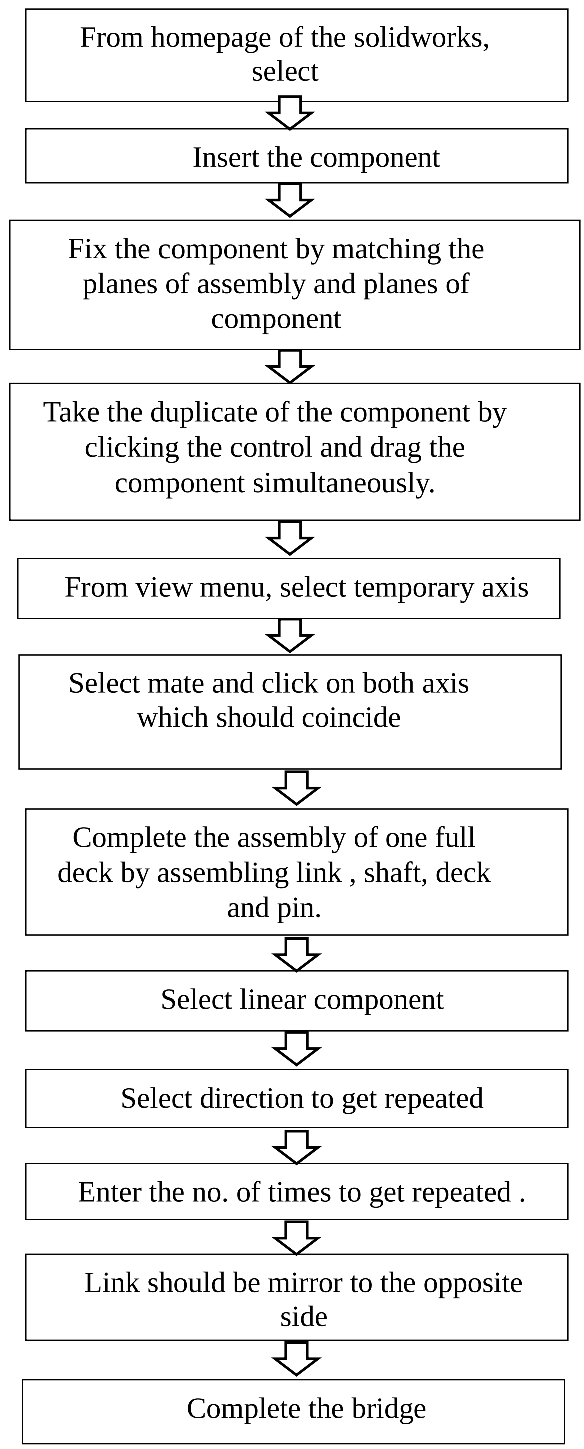



Fig 2: Assembling of Bridge



## AUXILIARY COMPONENT

The auxiliary parts included a single-acting hydraulic cylinder and a pump.

The term "single-acting cylinder" refers to a certain kind of cylinder where only one end is pressurised and the other end is vented or exposed to the atmosphere. The motion of the scissor bridge is governed by the principle of work and energy equation as shown in Eq (1).

$T_1+\sum U_{1-2}=T_2$ (1)

$T_i = \frac{1}{2} m v_i^2$ (2)

$\sum U_{1-2} = F\Delta d + mgh$ (3)

$T_1$ represents the kinetic energy at the initial state and $T_2$ is the kinetic energy at the final state as shown in Eq.(2). Velocity $v_1$ at initial state is always equal to zero and velocity $v_2$ at final the state is a dependent variable. $\sum U_{1-2}$ consists of the work done by the piston inside the hydraulic cylinder and work done by gravitational force as shown in Eq.(3). The hydraulic cylinder force F is caused by hydraulic pressure and Δd is the piston displacement. The variable m is the total mass of the structure and g is the gravitational acceleration which is assumed to be 9.81 $m/s^2$ and both are constant. The vertical distance travelled by the bridge during expansion and retraction is given by h and can be found during the motion simulation. By solving Eq.(1-3), the hydraulic cylinder force F can be determined. By applying Eq.(4), the power of the pump P required to move the structure can be calculated. The pressure inside the cylinder p can also be determined by using Eq.(5) where A is the cylinder's constant cross-sectional area.

$P=Fv_2$ (4)

$p = F/A$ (5)

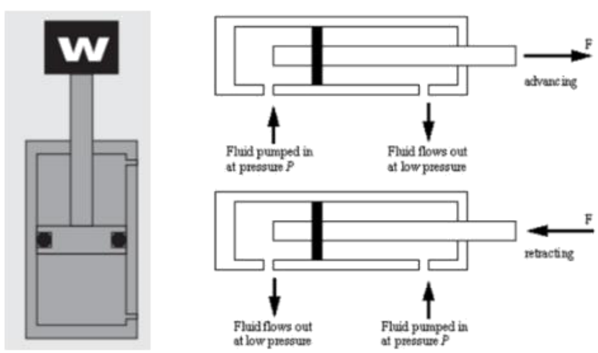



Fig No. 5 Single Cylinder

## RESULT AND DISCUSSION

The evacuation scissor-type bridge has revealed many benefits for the area. A dependable and secure means of transportation will be made available by the bridge. It will also be a great addition to the landscape and will be a great source of pride for the community. The design and modelling of the bridge are done using

SOLIDWORK Software that the components were modelled separately and the bridge is modelled by assembling the components altogether.

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