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Research Paper**VERTEX : The Vertical Rotary Bridge-2****Prof. C. A.Chitkeshwar,****Kallyani Dadarao Bhatkar****Manthan Rajesh Bhutad****Omprakash Bhagchand Kasture****Pravinkumar N Kuche****Bharti Kishor Rathod**

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ABSTRACT Transportation and connectivity between locations separated by considerable differences in elevation remain significant challenges in hilly, mountainous, and geographically constrained regions. Conventional solutions such as roads, bridges, tunnels, and switchback routes often require substantial land alteration, high material usage, and continuous maintenance, prompting exploration of alternative approaches that may provide more direct and controlled connection between different elevation levels. In response to this need, the present study proposes VERTEX, a conceptual vertical rotary bridge system designed as an innovative rotary transportation concept. The VERTEX concept envisions a large rotating wheel structure supported by a central axle with passenger cabins mounted at defined positions along the rotating frame. Unlike conventional bridges that provide a fixed horizontal link, VERTEX employs controlled rotational motion to transport passengers between different levels. The proposed system integrates principles of structural engineering, mechanical rotation, cabin stabilization, and transportation infrastructure planning. The rotating mechanism is envisioned as a balanced frame rotating about a central shaft or axle. Cabin stabilization is central to passenger safety and comfort. Because cabins attached to a rotating wheel naturally change orientation as the structure turns, a stabilization mechanism would be required to maintain an upright or near-upright position. Possible approaches may include pivoting cabin mounts, counterweight systems, or guided suspension mechanisms. Structural analysis would play a major role in assessing stresses, deflections, buckling risks, and behaviour under combined loads. Finite element modelling could be used to simulate static and dynamic load cases. Environmental factors such as wind loads, weather exposure, and material degradation would necessitate careful design detailing and maintenance planning. Safety is a fundamental requirement, including emergency braking, controlled acceleration and deceleration, mechanical locking mechanisms, position sensing, and structural health monitoring. Station design would require accurate alignment for boarding and disembarking, coordinated control of cabin movement and speed reduction. The foundation and support structures would need to accommodate site-specific ground conditions, potentially requiring deep foundations or reinforced configurations adapted to hilly terrains. The proposed research methodology includes conceptual development, mechanical calculations, structural modelling, finite element simulations, and scaled prototype testing. A scaled prototype would allow observation of cabin orientation, mechanical stability, and basic control principles, providing preliminary evidence for or against feasibility. While the concept is not presented as an immediate practical construction project, it aims to establish a technical foundation for further research into rotary transportation systems. Keywords: vertical rotary bridge, rotary transportation system, rotating wheel structure, vertical transportation,

cabin stabilization, structural analysis, finite elements, alignment, drive mechanism, dynamic behaviour, safety system, hilly terrain transport, prototype development.

Basic Structural Arrangement

A conceptual VERTEX bridge may consist of the following major elements.

Main Bridge Deck

The deck carries the traffic loading and forms the principal movable structural component.

Possible structural forms include:

- Steel plate girder
- Steel box girder
- Steel truss
- Composite steel-concrete deck

For an initial prototype, a lightweight steel box or truss arrangement may be advantageous because reduction of moving mass directly reduces the requirements imposed on the actuation system.

Supporting Towers

Two or more towers may be positioned on the sides of the navigation channel.

Their functions include:

- Supporting the lifting mechanism
- Housing machinery
- Providing vertical guides
- Supporting counterweights
- Resisting operational and environmental loads

The towers must be designed for both conventional structural loads and additional forces generated by the movable mechanism.

Rotary Axis

The rotary mechanism is the distinguishing feature of VERTEX.

A heavy-duty bearing or shaft arrangement can be provided at an appropriate structural node.

The rotary axis must be capable of transferring:

- Vertical reactions
- Horizontal reactions
- Torsional moments
- Operational forces
- Accidental loads

The bearing arrangement would require careful consideration of fatigue, wear, lubrication, contamination, corrosion, and maintenance access.

Vertical Guide System

Vertical guides constrain the movable span to its intended trajectory.

Possible systems include:

- Roller guides
- Linear bearing arrangements
- Guide rails
- Wheel-and-rail systems
- Hydraulic guide cylinders

The guides must prevent excessive lateral displacement during movement.

Operating Principle

The VERTEX operating cycle can be divided into six stages.

Stage 1: Normal Traffic Position

The deck remains locked to the fixed approaches. Traffic can cross the bridge.

Stage 2: Traffic Clearance

Traffic signals and physical barriers prevent vehicles and pedestrians from entering the movable span.

Stage 3: Structural Unlocking

Mechanical locks release the bridge after sensors confirm that the deck is unloaded and safe to move.

Stage 4: Vertical Movement

The lifting mechanism raises the bridge through its guided vertical path.

Stage 5: Rotary Movement

After reaching a predefined elevation, the rotary mechanism changes the orientation of the movable span.

The exact angle would depend on the final engineering configuration. A 90° rotation could be considered for a conceptual prototype, although the optimum angle should be determined through geometric and structural analysis rather than assumed.

Stage 6: Open Position

The bridge reaches its predefined safe position and is mechanically locked.

The navigation channel is then available for vessel movement.

Mechanical Drive System

The VERTEX system could employ one of three primary actuation approaches.

Electric Motor and Gearbox

An electric motor connected to a reduction gearbox could operate the lifting and rotary systems.

Advantages include:

- Precise control
- High automation potential
- Easy integration with sensors
- Regenerative or controlled braking possibilities
- Low local emissions

The drive system must be selected based on torque, speed, acceleration, duty cycle, and safety requirements.

Hydraulic Actuation

Hydraulic cylinders could be used for vertical lifting and rotary positioning.

Advantages include:

- High force density
- Compact actuators
- Smooth low-speed movement
- Good controllability

However, hydraulic systems introduce pumps, valves, hydraulic fluid, seals, leakage risks, and additional maintenance requirements.

Structural Loading

The bridge must be designed for several categories of loads.

Dead Load

Includes:

- Deck
- Girders
- Truss
- Wearing surface
- Railings
- Mechanical equipment

Live Load

Includes:

- Vehicles
- Pedestrians
- Maintenance equipment
- Rail traffic, where applicable

Environmental Load

Includes:

- Wind
- Temperature
- Rain and water effects
- Flood conditions
- Ice where applicable

Special Loads

Includes:

- Vessel collision
- Braking and acceleration
- Seismic loads
- Machinery forces
- Emergency stopping
- Accidental impact

Conclusion

- VERTEX — the Vertical Rotary Bridge — is proposed as an innovative movable-bridge concept combining vertical translation with controlled rotary motion. The concept is inspired by established movable-bridge technologies, particularly vertical-lift bridges, while introducing an additional degree of movement intended to provide a compact operating configuration.
- Existing engineering research confirms the feasibility and historical maturity of vertical-lift bridge technology. Modern design standards address the structural, mechanical, electrical, hydraulic, seismic, vessel-collision, and operational aspects necessary for safe movable bridges.
- The main potential advantage of VERTEX is its ability to combine the clearance characteristics of vertical movement with the spatial flexibility of rotary movement. This could make the concept attractive for constrained urban waterways, canals, ports, and specialized transportation infrastructure.
- However, the introduction of rotational movement also creates additional structural and mechanical challenges. In particular, synchronization, torsional behaviour, bearing loads, dynamic effects, fatigue, wind loading, emergency operation, and control-system reliability require detailed investigation.

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