Typical TMS temporary bridge structure in use after a flood

Bridging the Gap

Loading capacity simulation for temporary bridges assists in providing effective disaster relief.

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When natural disasters such as wide-scale flooding occur, transportation routes become critical in providing help to the afflicted area. Supplying a method for relief vehicles to safely cross rivers is extremely important during these periods. In the Czech Republic and many other countries, these relief efforts might involve assistance from allied countries within the North Atlantic Treaty Organization (NATO).

The temporary bridge tezka mostova souprava (TMS) was developed for military use between 1950 and 1960 in the former Czechoslovakia. The TMS bridge is a single-line, steel truss structure with a wooden deck well-suited for spans (distance between the supporting piers) of between 21 and 39 meters. The bridge design can be used in many configurations such as single-span, double-span, triple-span, and single-sided or double-sided, as well as single-story or double-story. This type of construction is commonly used instead of permanent bridges during bridge repair or for temporary bridging in an area affected by a disaster, such as a flood or landslide.

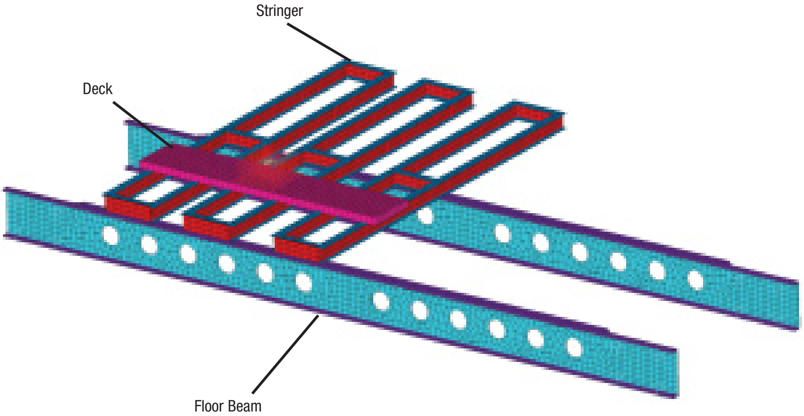
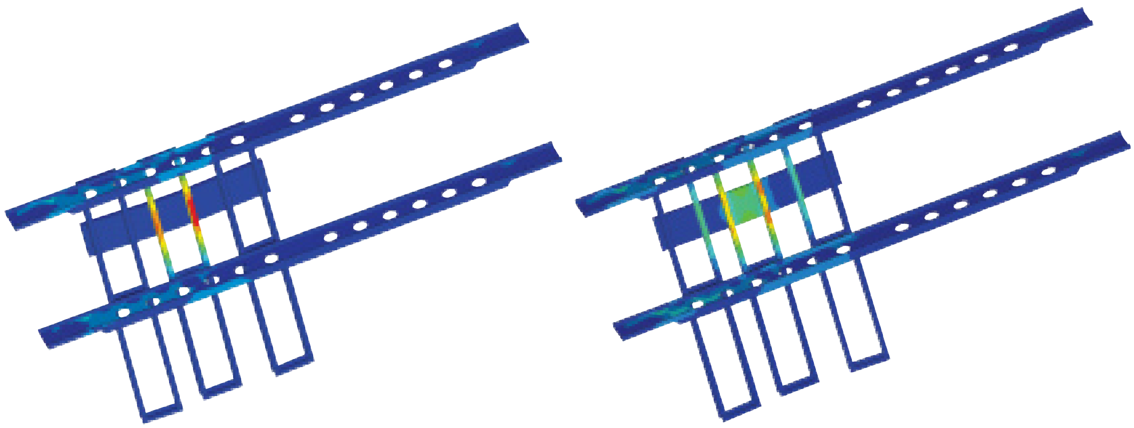


Diagram of a typical TMS bridge construction

The NATO Standardization Agreement 2021 (NATO STANAG 2021) helps establish a standard method of computing the military classification of bridges, ferries, rafts and land vehicles. Under this agreement, every bridge can be assessed with a specific load capacity classifying number — military load class (MLC) — and every vehicle is assigned to a specific category from 16 MLC classes. If the vehicle category MLC is lower or equal to the bridge MLC, that vehicle can safely pass over that bridge. This methodology is independent of various national codes, such as EC standards from the European Union or DIN standards from Germany, and allows closer interoperability between NATO countries.

The University of Defence, in cooperation with Czech Technical University and funded by the Ministry of Transportation of the Czech Republic, set



Simulation of the wooden deck (left) showed minimal load distribution between stringers whereas, simulation of the steel grid deck (right) indicated significant load distribution based on a tire load of approximately 9.07 tons and a contact area of 400 mm by 400 mm.

out to certify the loading capacity of TMS bridges according to the NATO guidelines. ANSYS Mechanical software was used to assist in classifying various decks for existing bridges, as well as for new designs.

TMS bridges traditionally had wooden decks. Simulations revealed that the flexible wooden boards did not distribute tire loads effectively, causing the stringer directly under the tire to be highly stressed. As a result, the overall bridge rating was limited to MLC-70 (approximately 70 tons) when wood decking was used, even though the other structural components of the bridge could be rated for MLC-90 (approximately 90 tons) for some shorter spans. Consequently, three different decking systems — wooden decking, welded steel panels and a new design of welded steel grid decking — were analyzed to find a way to upgrade the floor rating to MLC-90, consistent with the rest of the structure.

The simplest model consisted of decking and stringers. In the early stages of the study, this model used shell elements, but in later simulations the CAD geometry was meshed directly with solid continuum elements. ANSYS Mechanical software allowed for easy import of CAD data from Autodesk® Inventor™ and supported a legacy database from previous versions of ANSYS Mechanical software, so data could be reused. The model included contact, available through the ANSYS Workbench environment, between the decking and stringers.

The welded steel panel design developed about 10 years ago as an alternative to the wood decking and stringer system was modeled in Autodesk Inventor and imported into the ANSYS Workbench environment as an isolated component using solid elements. This model was analyzed as a linear elastic structure without contact. The welded panel had a high safety factor even under MLC-90 loading, but the expense of this design led to its rejection for military use, though it is still used in some urban areas, as it is quieter than a wooden deck.

In addition, a model of a single floor beam was analyzed to determine the effect of nonlinear responses, such as plasticity and lateral buckling, on its load-carrying capacity. This model used solid elements with bonded contact at bolted connections and frictionless contact at other interfaces between parts. The floor beam was found to be adequate for MLC-90 loading.

Finally, a complex model of deck, stringers and floor beams was analyzed to provide the most accurate interaction among all the components of the floor system. To minimize solution times, this model was analyzed using shell elements (no solid elements) and appropriate contact formulations. This model was investigated for both wooden decking and steel grid decking. The analyses revealed that steel grid decking effectively distributed tire loads to adjacent stringers, reducing the stress in the stringers and enabling the floor system to be rated at MLC-90. Based on these structural analyses, a new bridge deck composed of the welded steel grid was designed to enable better deployment of assistance to address a crisis situation. ■

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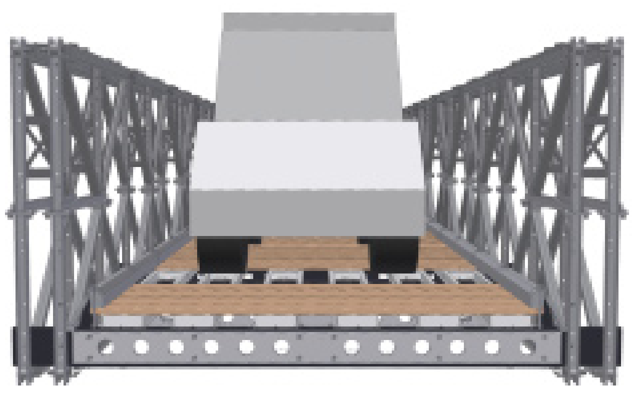

CAD model of TMS temporary bridge construction and military vehicle