



Yi Sun-sin bridge, constructed by DAELIM Korea

## RM Bridge Advanced Additional Modules

Bridge Structural Modeling, Analysis, Design, and Construction Engineering

RM Bridge Advanced V8i is comprehensive 2D/3D/4D software used by bridge engineers for bridges of all types, materials, and construction methods. A fully integrated modeling, analysis, and design process and rapid results processing bring economy to bridge design. RM Bridge Advanced produces deliverables derived directly from the models being analyzed – improving bridge constructability and ensuring smooth project delivery. RM Bridge software comprises a selection of advanced modules for the intensive analysis requirements of complex bridge types, such as long-span, cable-stayed, and suspension bridges. Add-on modules address specialized activities such as advanced earthquake analysis, rolling stock analysis, erection control, simulation of wind-tunnel tests, wind buffeting, as well as a variety of construction and fabrication methods such as incremental launching, in-situ casting and others.

### RM Bridge Advanced Non-linear

Additional module RM Bridge Advanced Non-linear provides all advanced features dealing with non-linearity of the structural behavior. This relates to large displacement geometric non-linearity as well as to advanced material non-linearity (inelastic hysteretic behavior).

Material non-linearity covers special effects like elastic non-linear behavior, inelastic behavior, multiple dependency of constitutive laws on several state parameters, cracked concrete with reinforcement and prestressing, redistribution of stresses in composite sections, proper follow up of the stress and strain state throughout the construction schedule, load stepping action for determining the formation of plastic hinges (push-over analysis).

This module also contains various advanced highly non-linear spring elements with multiple dependencies and/or hysteretic behavior (e.g. special rail-track interaction springs, hysteretic friction elements, etc.).

Consideration of large displacement represents an important part of non-linearity and is required for failure analyses (stability), proper handling of movable devices such as roller bearings, accurate pre-cambering procedures in construction engineering, dealing with bascule bridges, and so on.

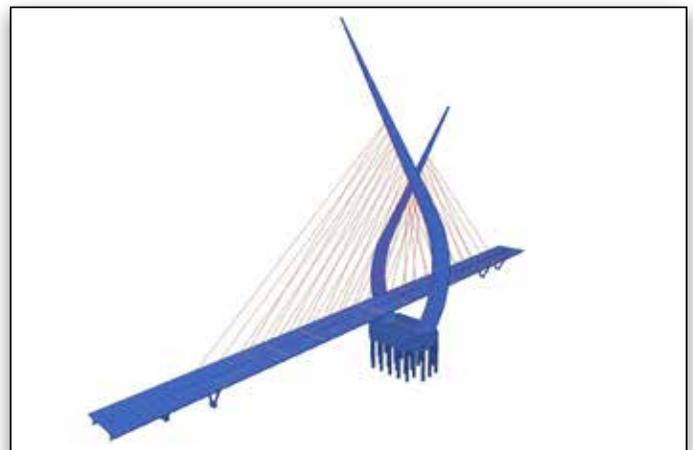
All non-linearity effects can be combined and properly followed up throughout the construction schedule. A robust iteration scheme allows fast convergence even in cases with extraordinarily high non-linearity.



*Calculate non-linear effects of cable sagging.*

### RM Bridge Advanced Cable

Special option for sophisticated non-linear calculation of cable-stayed and suspension bridges including calculation of non-linear effects of cable sagging. The powerful optimization solver ADDCON for supports form finding processes of



*Wear Crossing Bridge, Mott MacDonald, UK.*



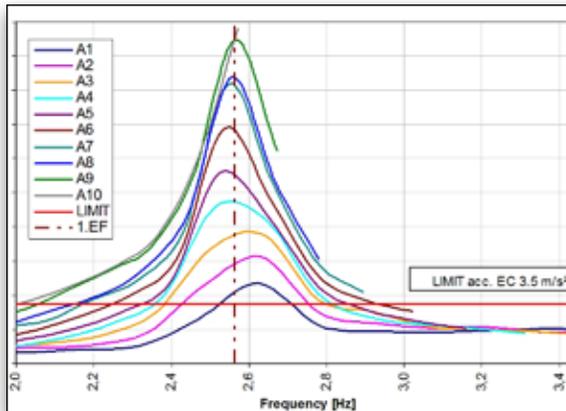
## RM Bridge ensures bridge constructability and improved design.

suspension cables and optimization stay cable tensioning sequences in both, linear and non-linear final state analysis as well as construction stage analysis process.



*Sutong Bridge, HPDI China.*

A powerful preprocessor for all kinds of cable-stayed bridge allows for extremely efficient data preparation. The preprocessor, together with the optimization tool ADDCON, it makes the product the world's leading tool for the design of large-span, cable-stayed bridges and suspension bridges.



*Rolling Stock Tool.*

### RM Bridge Advanced Dynamics

The option RM Bridge Advanced Dynamics allows for performing special tasks in earthquake engineering and high-speed rail design. An implicit non-linear time history algorithm is used. Time dependent load, time dependent masses and highly non-linear damping devices can be considered. The seismic excitation can be defined either by relevant accelerograms or ground motion histories.

The procedure uses Rayleigh damping for structural elements and allows for considering different special damping devices (seismic isolators). Various types of damper elements are offered, such as

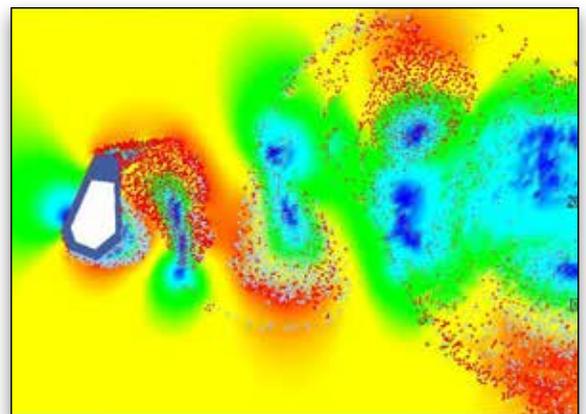
linear and non-linear viscous dampers, friction-based dampers (FPS) and elements combining elastic and viscous behavior (Maxwell damper, Jarret device).

For HSR design the offering contains a special function for fast investigation of the resonance behavior of a bridge, considering a set of various load trains passing the bridge with different velocities (rolling stock). Results are the relevant maximum displacement accelerations during the train transits with different speeds. A detailed analysis for relevant train transit events can be performed by taking over train and velocity data from this function or by using the powerful preprocessor for moving load definition.

### RM Bridge Advanced Wind

RM Bridge Advanced Wind covers 3 major topics relevant to bridge design for assessment of wind impacts:

- CFD calculations simulating wind tunnel tests by calculating aerodynamic coefficients and their derivatives using the mathematical approach of computational fluid dynamics. A CFD calculation is mainly based on input of cross section, wind velocity, and wind direction. The CFD module is equipped with a mechanism to suggest meaningful calculation parameters, which can be tuned manually. The calculated time histories of drag, lift and moment can be exported either as plots or Excel worksheets, and the whole calculation can be stored as video. Once a set of parameters is fixed, it can be stored and loaded from the RM database. The parameters for the AERO schedule action can now be set directly from the CFD calculation panel. Next to static cross sections, moving cross sections can be calculated now, and a direct calculation of flutter derivatives is possible. To speed up calculation, the CFD module now offers a multithreading option.
- Performing sophisticated wind buffeting analyses taking into account dynamic wind effects (turbulences), interaction between wind and vibration modes of the structure and structural and aerodynamic damping. Wind buffeting analysis must take into account the random properties of wind events, which are described by wind power spectrum and coherence. Detailed information of



*CFD calculation – Wear River Crossing Bridge, Mott MacDonald, UK.*



*Maguga Bridge in Swaziland, VKE – SMEC South Africa.*



*Uddevalla (Sunningesund) Bridge, Sweden Johs Holt, Norway.*



*Yi Sun-sin Bridge, constructed and built by DAELIM South Korea.*



*Stonecutters Bridge, Ove Arup and Partners, Hong Kong.*

the considered structure must be provided, which is done in form of eigenmodes and frequencies. This information is combined in a statistical analysis method to provide information about the structure peak response due to a given wind profile.

- Performing relevant wind design code checks (vortex shedding, across wind galloping, torsional divergence, classical and torsional flutter)

### **RM Bridge Advanced Construction**

This option addresses the requirements of special advanced construction methods and erection control functionality. Used in the design phase, it allows considering in detail the influence of special construction techniques (e.g. incremental launching method) and providing exact data on deformation states throughout the erection process and camber requirements.

In bridge engineering, lifting and launching processes become more and more important due to the cost reductions often achieved by prefabricating superstructure segments in a workshop or a stationary place near the actual construction site.

Despite the costs for the required lifting, or launching equipment and for accomplishing the transport, lifting or launching process, the total costs are often much less than those arising when fabricating the whole superstructure in place.

However, these lifting and launching techniques require sophisticated analyses of the arising stresses throughout the whole installation or advancing process.

A special function provides comprehensive geometric data for precast segmental structures to be used in RM Bridge Cast for control of the casting machine in match cast processes. The erection control and monitoring functionality of this module can efficiently be used in construction engineering where control analyses accompany the erection process, deviations from the design state are tracked in an early state, and required compensation measures can be developed in time by the construction engineers.

For long-span, cable-supported bridges, special suspension bridges, simulation of the erection process represents a great challenge. Asymmetric loading due to traffic causes large displacements and requires non-linear traffic analyses. The procedure of connecting the different girder segments individually to their respective hangers causes continuously considerable changes to the sagging curve of the suspension cables due to the weight of the already mounted segments. This leads to high up and down movements of the deck segments during erection. Structural assembly in RM Bridge erection control mode can be used to fully simulate certain construction conditions.

### **RM Bridge CAST**

Due to various advantages precast segmental construction techniques have become very popular in bridge engineering. These advantages are:

- Better quality due to production in a controlled environment
- Less formwork needed
- Less invasive (disturbance of traffic, environmental, etc.)
- Accelerated construction time

## System Requirements

### Processor:

Intel or AMD processor 2.0 GHz or greater

### Operating System:

Windows XP (SP2 or later), Windows Vista (SP2 or later), Windows 7, Windows 8

### RAM:

1 GB minimum, 4 GB recommended. More memory almost always improves performance, particularly when working with larger models.

### Hard Disk:

1.4 GB MB free disk space

### Display:

Windows-compatible graphics card and monitor supporting at least 1280 by 768 resolution and high or true colors. DirectX 9.0

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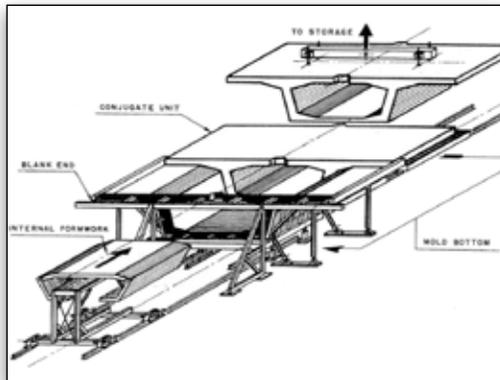
However, this construction technique requires a very accurate geometry definition such that the assembled structure matches the intended geometry and fits into the boundary conditions on site. Specifying the exact geometry of each segment is indeed a great challenge, especially if the structure is curved and/or pre-cambered. Due to its advantages "short-line match casting" has become the most popular casting method for precast segments.

RM BridgeCast is used for controlling the casting process. Based on the intended stressless geometry described by the casting curves defined in the database file, the user can interactively use the program for adjusting the casting machine to cast the individual segments (placing the match cast segment, adjusting the soffit), and check the actual shape after casting

(detecting errors due to the casting process) and for considering these errors to correct them when casting the subsequent segments.

The casting curves accurately describe the stressless geometry of the superstructure or structural parts built up by the segments of the individual casting sets.

The casting curve of the nodes is defined by the design shape (any curvature of the target axis in plan and/or elevation) and – if required – any pre-camber values to be added to achieve the design geometry under permanent loads. The casting curves of the rivet points also define the cross-fall of the cross-section surface.



RM Bridge CAST.



RM BridgeCast is used for controlling the casting process.



Sheik Zayed Bridge in United Arab Emirates, by High Point Rendel.