Bentley®
Advancing Infrastructure

CONNECT Edition

Mokpo Bridge by GS Engineering & Construction Corp. Korea

RM Bridge

Advanced Bridge Modeling, Analysis, Design, and Construction Engineering

RM Bridge CONNECT Edition is comprehensive 2D/3D/4D software used by bridge engineers for bridges of all types, materials, and construction methods. RM Bridge CONNECT Edition is a fully integrated modeling, analysis, and design application that produces deliverables derived directly from the models being analyzed – improving bridge constructability and ensuring smooth project delivery.

The CONNECT Edition

The SELECT® CONNECT Edition includes SELECT CONNECT*services,* new Azure-based services that provide comprehensive **learning, mobility,** and **collaboration** benefits to every Bentley application subscriber. *Adaptive Learning Services* helps users master use of Bentley applications through CONNECT Advisor, a new in-application service that provides contextual and personalized learning. *Personal Mobility Services* provides unlimited access to Bentley apps, ensuring users have access to the right project information when and where they need it. *ProjectWise® Connection Services* allow users to securely share application and project information, to manage and resolve issues, and to create, send, and receive transmittals, submittals, and RFIs.

RM Bridge follows an iterative modeling and analysis process that gives users remarkable flexibility in the bridge design process. It puts an end to costly start-over tasks that occur in midstream with the added benefit of ensuring that an efficient and balanced project is delivered. This enables engineers to achieve extreme accuracy and go to unprecedented levels of analytical exploration and simulation. The software provides seamless support for required international design codes.

Choose the Version That's Best for You

Because every organization's needs are different, RM is offered in three options:

RM Bridge is the most standard application. It is suitable for analysis, design, and load rating of concrete, steel, and timber bridges of all types including girder, truss, arch, and segmental. It can be used on straight, curved, and skewed bridges as well. RM Bridge supports over 20 international design codes. The analyses methods include static and linear dynamic analysis, soil-structure interaction, time-dependent creep and shrinkage analysis. Support for unlimited number of construction stages makes the product suitable to address complex construction sequences. RM Bridge also offers Wizards for rapid model creation, interoperability with Bentley civil software, and OpenBridge Modeler.

RM Bridge Advanced extends the standard RM Bridge capabilities to non-linear analysis, FEM, Push Over, Time-History, and High-speed Rail analysis. It includes the specialized Balanced Cantilever device for easier generation of construction sequence for segmental bridges, and a cast device for setting up segment geometry in the casting yard.

RM Bridge Enterprise is the most comprehensive version of RM. It extends RM Bridge Advanced capabilities to cable-stayed and suspension bridges. It also includes advanced hydrodynamic and wind analyses, and specialized capabilities

for advanced construction methods such as – Erection Control for shape adjustment during construction and Incremental Launching for building bridges overhead with no temporary support or false work.

Develop a Complete Bridge Project

RM Bridge provides engineers broad flexibility in the development of a complete bridge project, saving time and improving project delivery. Substantial static and dynamic analysis capabilities allow for addressing a wide range of bridge engineering problems. The ability to model time-dependent material effects and analyze construction staging provides distinct competitive advantages. Expert parametric geometry definition and control, as well as easy modification, aid in construction management, erection simulation, and seismic analysis. Automated processes like direct delivery of design data to casting and fabrication help save time and shorten project cycles. Users can even provide project stakeholders with open, browser-like access to the bridge design project for viewing, redlining, printing, and plotting. Batch and interactive mode as well as programming capabilities make the application very attractive for quick and easy use. Connection to Bentley inspection applications highlights RM Bridge as all-in-one solution – even in the maintenance process of the bridge lifecycle.
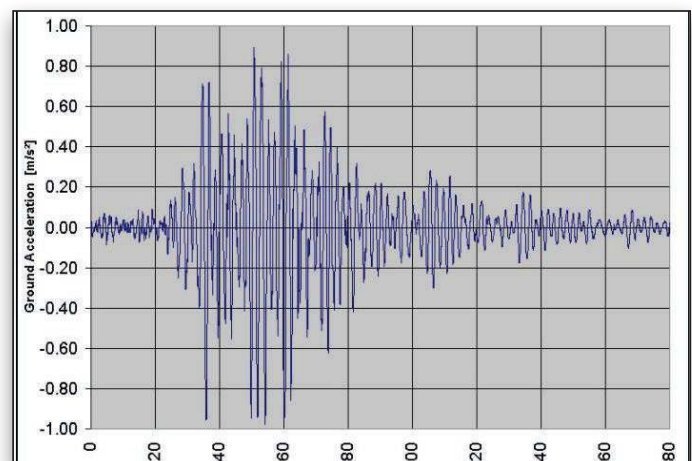

Acceleration diagram – time history calculation.

Integration with Multi-discipline Engineering Applications

Unlike comparable bridge software, RM Bridge performs well in the context of the infrastructure project. The software shares data in MicroStation® DGN, LANDXML, DWG, and other formats. This capability enables the engineer to accurately define the bridge based on the roadway or railway axis geometry from Power Rail Track, OpenRoads, or alternatively from AutoCAD, Civil 3D, and other partial applications. With RM Bridge the bridge engineer has a wealth of civil project information at hand:

roadway horizontal alignments, vertical profiles, photogrammetric data, digital terrain models, isolines (contour lines), raster graphics, and rail line designs. Two-way interoperability with OpenBridge Modeler allows users to bring OpenBridge Modeler models into RM Bridge for analysis and bring as-designed prestressing tendons back into OpenBridge Modeler. The enhanced model aids in preparing more complete material quantity estimates and in construction planning. With RM Bridge, your bridge design and construction data goes beyond design and engineering needs to inform downstream processes such as fabrication, construction, operations, maintenance, and inspection.
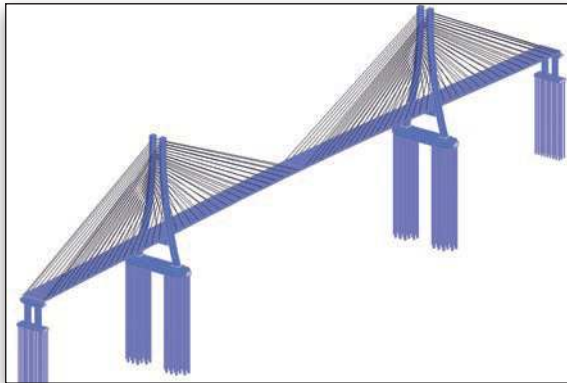
Predict performance with RM.

Design Many Bridge Types

RM Bridge addresses all typical bridges, from reinforced and pre-stressed concrete to steel and composite bridges. It performs consistent time-dependent analysis of creep and shrinkage and steel relaxation. Users analyze the deformability of the superstructure and consider in detail the used construction methods and sequences as well as interactions between the superstructure and substructure or structure and soil. RM Bridge streamlines analysis of pre- and/or post-tensioned concrete structures (for internal and external tendons), steel and composite structures with pre-stressed structural parts. The software also solves a full range of common composite structure problems and calculates the effects of different strengths and ages of concrete, accounting for creep and shrinkage differences among the various components. In addition, the software supports both prefabricated and cast-in-place construction methods.

Integrated Modeling and Analysis

A bridge modeler runs in sync with an ingenious bridge solver to streamline the management of geometry data for detailed design and drawing production. Using the bridge modeler, engineers define the entire structural system, including support conditions, substructures, and cross members. The software ensures that geometric cross-sectional data and the structural calculation model correspond. It produces a fully defined structural model with complex definition of individual cross sections, ready for structural analysis. The bridge solver performs an impressive array of analytical operations, calculating bridge performance in virtually any condition or situation. Data is reprocessed by the modeler and the solver as many times as necessary to reach the desired results. The possibility of defining tables and formulas as database objects assigned to individual data is an efficient

means to account for variability of the model geometry as well as governing parameters in the analysis process. RM Bridge handles linear dynamic bridge analysis. The offering covers the relevant functionality for earthquake design, i.e. calculation of natural modes and response spectrum analysis. Another relevant topic of RM Bridge excellence is its comprehensive functionality for pre-stressing, including sophisticated tendon geometry definition.

4D Stage Analysis and Schedule Variants

With a fully defined 3D bridge model, users evaluate all aspects of a stage-wise erection of the bridge structure. The 4D analysis capability makes it easy to develop a construction schedule that defines the sequence and content of arbitrary construction stages. Users can define the stages up to the level of complexity required. Activation or deactivation of any part of the bridge structure at any time during the construction process marks RM Bridge as a real-time bridge design and construction application. National code requirements are predefined in RM Bridge, enabling users to quickly design to code. Creep, shrinkage, and steel relaxation are defined in the "construction schedule." A special time-dependent E-modulus function accounts for concrete hardening. Schedule Variants may be used to analyze a structure in different ways: linear, dynamic, stage per stage, final calculation. The same geometrical model can be used for different analytical purposes to secure efficient handling and time savings.

Time-dependent Effects

An integral part of the 4D analysis is considering the behavior of the structure in space and time. Engineers can draw from the full array of analytical capabilities to investigate the many phases of the structure up to completion, considering all time-dependent material characteristics, such as creep, shrinkage, and relaxation. All resulting redistributions of internal forces are accurately taken into account.

Traffic Loading

RM Bridge enables users to analyze traffic loading according to design code or custom standards, including all loading combinations and details, while achieving substantial time savings. For standard structures, RM Bridge uses influence lines for calculating the worst effects of traffic loading.

Seismic Analysis

RM Bridge Advanced delivers response-spectrum analysis for determining the effects of potential seismic events. Users define the response spectrum in a table inclusive of any number of values given as displacement, velocity, or acceleration. Individual results are combined using different stochastic superposition rules: ABS-rule, SRSS-rule, DSC-rule, and CQC-rule. Special RM Bridge superposition rule is included, obtaining corresponding results to leading values in response spectra analysis.

Envelopes for stresses, internal forces and displacements are given as results. By incorporating set-offs of time history for different structural elements, engineers can calculate phase differences between two foundations in earthquake conditions. Special damping effects and other conditions can also be considered during seismic analysis.

Loading and Load Combinations

During analysis, the bridge solver applies all loadings on the active

structural subsystem at the most relevant point in time. The software automatically calculates differential load cases during construction stage analysis by taking into account the correct nonlinearity effects. The results of a summation load case are used to calculate the nonlinear stiffness matrix for analysis and design. Using the load combination table allows for a clear and easy creation of design code related envelopes. By specifying multiplication factors (separately for favorable and unfavorable), combinations for serviceability and ultimate limit state checks are created in a consistent way.

Once load cases are calculated, the program automatically runs stability checks by increasing the loading until bifurcation occurs. Engineers run loads iteratively until reaching stability. The ultimate load capacity of the structure is calculated by performing nonlinear analysis for different load increments, and deduced from RM Bridge calculated load displacement diagrams.

Rating and Design Code Checks

RM Bridge provides extensive design code checking and supports the locally relevant design code. An upgrade to RM Bridge Advanced offers a full array of international design codes. Users can activate code checks at any time during a particular construction phase or final stage. The system provides graphical viewing of all code checking and automatically notates points where design values exceed resistance values. Based on the different result envelopes for dead loads and live loads the program allows for evaluating load rating factors in accordance AASHTO LRFD specifications.

Post Processing and Script Interface

RM Bridge offers different options of result control for each point of the bridge structure for any point in time in the bridge 4D schedule process. Due to its flexibility RM Bridge is very well suited for preliminary design as well as detailed design tasks. Easy refinement and modification of the mathematical model makes it also predestined for application in construction engineering. RM Bridge includes a comprehensive scripting interface in script language. The complete binary RM Bridge input database has a text equivalent in script commands. Those scripts are very concise and readable ASCII-text files containing optimally sized RM Bridge project data. Furthermore, those scripts may be used to access the result database of RM Bridge for user-defined output and additional processing.

Non-linear Analysis with RM Bridge Advanced

The non-linear analysis feature covers all aspects of 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 such as 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 feature also offers 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.

Advanced Dynamic Analysis with RM Bridge Advanced

The advanced dynamics capability allows for performing special tasks in earthquake engineering and high-speed rail (HSR) 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.
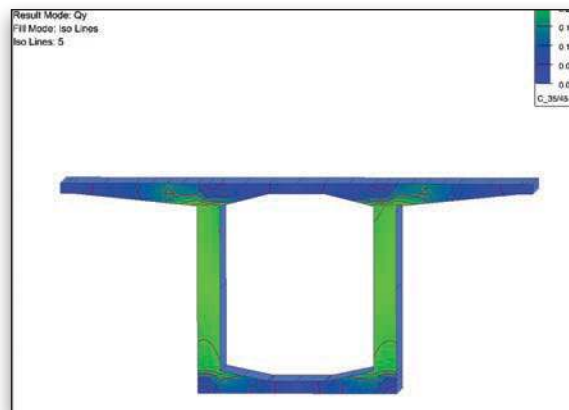
Shear Stresses.

Cable Analysis with RM Bridge Enterprise

Special option for sophisticated non-linear calculation of cable-stayed and suspension bridges including calculation of non-linear effects of cable sagging. The optimization solver ADDCON supports finding processes of suspension cables and optimization stay cable tensioning sequences in, linear and non-linear final state analysis as well as construction stage analysis process.

A powerful preprocessor for all kinds of cable-stayed bridge allows

for extremely efficient data preparation. The preprocessor and ADDCON makes RM Bridge a leading application for designing large-span, cable-stayed bridges and suspension bridges.

Advanced Wind Analysis with RM Bridge Enterprise

The advanced wind analysis capability covers three 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 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. Calculate aerodynamic coefficients and their derivatives for any bridge or pylon cross-section, eliminating the need for wind tunnel tests in preliminary design. Consider the aero-elastic behavior of the structure and the wind loading correlation with wind buffeting analysis in time domain on ultra-long span and floating suspension bridges. Perform a complete analysis of the combined wind and wave forces, as well as other time-dependent loads such as earthquake loads, moving loads, and wave loads.

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

Advanced Construction Methods with RM Bridge Enterprise

Two special features, namely, Erection Control and Incremental Launching, address the requirements of special advanced construction methods and erection control functionality. Used in the design phase, it considers in detail the influence of special construction techniques (e.g. incremental launching method) and provides 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 control the casting machine in match cast processes. The erection control and monitoring functionality 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 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.

Casting Geometry with RM Bridge Advanced

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

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.

You can also control 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.

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