



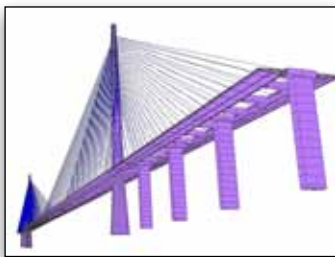
## RM™ Bridge Professional

Bridge Structural Analysis, Design, and Construction Engineering

RM Bridge Professional 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 Professional produces deliverables derived directly from the models being analyzed – improving bridge constructability and ensuring smooth project delivery.



Lawrence Hargrave Bridge, AECOM Maunsell Australia.



Stonecutters Bridge, Ove Arup and Partners Hong Kong.



Sheik Zayed Bridge by High Point Rendell.

### All-in-One Bridge System

Whether running stand alone or with other RM Bridge advanced programs, RM Bridge Professional 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 and has 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.

RM Bridge Professional is the core software of the RM Bridge family, which offers integrated modules for bridge engineering and construction. 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 rolling stock analysis, erection control, and simulated wind-tunnel analysis, as well as a variety of construction and fabrication methods such as balanced cantilever construction, incremental launching, and in-situ casting.

### Develop a Complete Bridge Project

RM Bridge Professional is an iterative system that provides engineers broad flexibility in the development of a complete bridge project, saving time and improving project delivery. Complete static and dynamic analysis capabilities help them address virtually any structural issue. The ability to model time-dependent material effects and analyze construction staging provides distinct competitive advantages. Expert parametric geometry definition and control 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.

### Infrastructure Project Definition

Unlike comparable bridge software, RM Bridge Professional performs well in the context of the infrastructure project. The software shares data in MicroStation® DGN, LANDXML, and other formats. This capability enables the engineer to accurately define the bridge based on the roadway or railway axis geometry from Bentley® InRoads®, GEOPAK®, Bentley® MXROAD®, or Bentley® Rail Track software, or alternatively from AutoCAD, Civil 3D, and other partial applications. With RM Bridge Professional, 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. All bridge design and construction data contributes to the process of bridge information modeling (BrIM).

BrIM is a new and innovative approach to bridge engineering and project delivery that fosters the use of data beyond design and engineering needs to inform downstream processes such as fabrication, construction, operation, maintenance, and inspection.

### Design Any Bridge Type

RM Bridge Professional addresses all types of bridges, from reinforced and prestressed concrete to steel and composite bridges, arch bridges, suspension and cable-stayed bridges, and more. It performs consistent time-dependent analysis of creep and shrinkage and steel relaxation. Users analyze the deformability of the superstructure and consider interactions between the superstructure and the substructure, as well as between the structure and the soil or surface.



*Synchronized modeling and analysis streamline the management of geometry data in a continuous cycle – no starting over.*

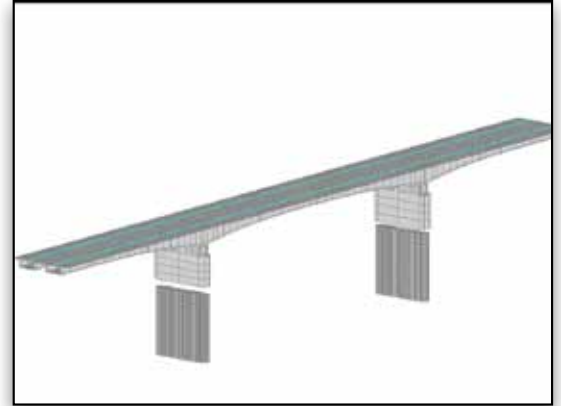
RM Bridge Professional streamlines analysis of pre-tensioned and/or post-tensioned concrete structures (for internal and external tendons), and provides for composite structures with prestressed structural parts.

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 a sophisticated 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.

RM Bridge Professional is renowned for its dynamic analysis capabilities, which manage traditionally complex engineering problems with ease and accuracy. A full array of mass and damping matrices and time-history capabilities – combined with fast calculation times – puts RM Bridge Professional in a class of its own. The types of analysis cover the gamut of bridge analysis needs: free-response analysis, response spectrum analysis, linear time-integration analysis, nonlinear time-integration analysis, tendon geometry and prestressing force distribution, load-case prestressing, load-case creep/shrinkage, and steel relaxation. (See the “At-a-Glance” section for capabilities.)



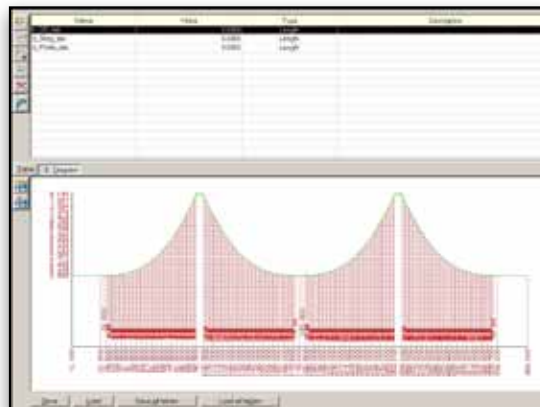
*Interactive bridge modeler enables creation of any bridge structure.*

Unique to RM Bridge Professional is its hybrid FEM analysis capability for detailed modeling of individual beam, wall, plate, shell, and volume elements. This method – modeling a set of FEM elements to act as substructure – delivers more accurate results than the conventional method.

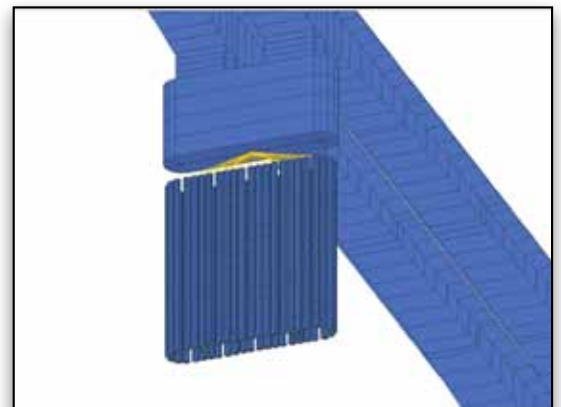
An additional plane rotation or drilling degree of freedom (DOF) can be incorporated for greater accuracy. Detailed hybrid results are integrated with traditional beam results for design code checks, post-processing, safety assessments, and delivery to code.

**Time-Dependent Effects**

An integral part of the bridge model is its ability to perform a complete 4D analysis, which enables engineers to consider 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: linear or nonlinear analysis, static or dynamic calculations, design code checks, load-case superposition and manipulation, generation of lists and plots or general file system operations, and more.



*Parametric definition of cross-section values (e.g. web) along the 3D bridge axis.*



*Soil-Pile interaction modelled by special spring elements representing soil properties.*

The software considers all time-dependent material characteristics, such as creep, shrinkage, and relaxation. All resulting redistributions of internal forces are accurately taken into account.

### Construction Methods

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. National code requirements are predefined in RM Bridge Professional, 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.

are combined using different stochastic superposition rules: ABS-rule, SRSS-rule, DSC-rule, and CQC-rule.

Envelopes for 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 Combination Loads

RM Bridge Professional employs second-order theory with P-Delta effects to accurately calculate load cases. It performs both linear and nonlinear analyses, which when combined provide distinct advantages in the design of steel and composite structures, new or existing.

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.

### Stability Checks

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 Professional calculated load displacement diagrams.

### Design and Design Code Checks

RM Bridge Professional provides extensive design code checking and supports 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.

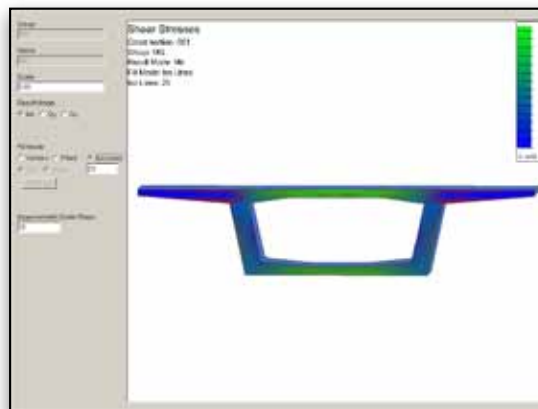
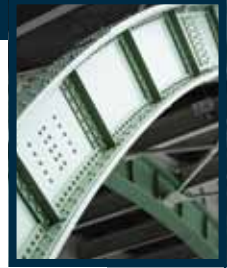
### Traffic Loading

RM Bridge Professional 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 uses influence lines and influence surfaces for calculating the worst effects of traffic loading.

For cases in which nonlinearity must be considered, RM offers a fast and effective means to calculate influence lines based on the tangential stiffness matrix, taking into account the nonlinearity effects due to permanent loads. Full nonlinear traffic load calculation is also achieved by generating the relevant load sets and nonlinear calculations of the respective load cases.

### Seismic Analysis

RM Bridge Professional 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



*Shear stress flow.*



*RM Bridge Professional is a powerful 2D/3D/4D system, proven on projects of all types, materials, and construction methods.*

## RM BRIDGE PROFESSIONAL AT-A-GLANCE

### Structural Elements

- Powerful parametric 3D modeler for the superstructure and substructure elements
- Pre-loaded comprehensive library of structural elements and sections
- Modeling using beam, spring, cable, friction, damper, plate, wall, shell, and volume elements
- Structural elements are defined with linear or nonlinear behavior
- All elements can have eccentric connection to the nodes
- Nodal supports with uncoupled stiffness for all six degrees of freedom (DOF)
- Arbitrary stiffness matrix or flexibility matrix for characterizing complex elements
- Large displacement effects
- Beam Elements
  - » Stiffness matrix calculated using material parameters
  - » Material nonlinearity
  - » Composite material interaction
  - » Creep, shrinkage, and steel relaxation features
  - » Shear deformation
  - » P-Delta effect
- Spring Elements
  - » Springs are individually defined by stress-strain diagrams
  - » Tension cut-off and compression cut-off definitions
- Friction Elements
  - » Stiffness for x displacement and all three rotations specified by spring constants

- » Stiffness in local y and z direction coupled with the compression force
- Nonlinear Damper Elements
  - » Uncoupled damping stiffness terms for all DOF
  - » Damping force defined as a function of the deformation velocity
  - » Viscous damper and damper spring elements
- Cable Elements
  - » Coupled axial-transversal behavior includes the sagging effect
  - » Automatic cancellation of compression forces
  - » Intermediate points can be used as local nodes

### Finite Element Modeling

- Linear structural analysis of systems using plate, wall, shell, and volume elements
- Special shell element with in-plane rotation DOF allowing for combination with beam elements
- Allows eccentric rigid links for all FEM element types
- Supports complex hybrid systems combining different element types
- Delivers detailed results for walls, plate, shell, and volume elements
- Automatic generation of beam-related results for use in design-code checks

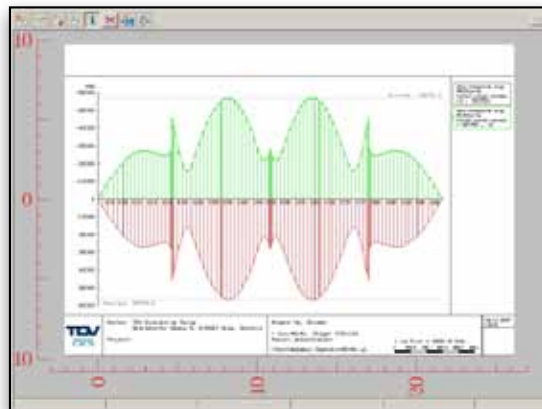
### Material Nonlinearity

- Preloaded standard material tables
- Predefined stress strain diagrams for both serviceability and ultimate state

- Nonlinear stress-strain diagrams for user-defined materials
- Nonlinear material behavior for structural, reinforcement, and prestressing steel and concrete
- Consideration of cracking concrete in the tensile zone of the cross section
- Calculates tensile zone and elastoplastic characteristics for all sections
- Calculates redistribution of deformations and internal forces
- Combines material nonlinear analysis with second-order theory calculation

### Static Analysis

- Linear and Nonlinear Analysis
  - » Nonlinear material behavior, springs, and dampers
  - » Cable sagging
- Traffic
  - » Automatic traffic load combinations
  - » Pre-loaded standard design trucks or user defined vehicles
  - » Traffic load calculation using lane-related influence lines
- Construction Stages
  - » Construction analysis by stage, subsystem, or complete system
  - » Creep and shrinkage behavior throughout construction
  - » Construction sequence simulation
  - » Automatic camber calculations for construction staging
  - » Reports generation at any stage



*Envelope results due to Response Spectrum Analysis.*



*Stresses are accurately determined during the construction schedule.*



### Dynamic Analysis

- Mass and Damping Properties and Time-Dependent Loads
  - » Rayleigh damping for time history
  - » Modal damping for modal analysis
  - » Defined nonlinear dampers included
  - » Single-loading cases comprising combinations of load sets multiplied by time-dependent factors
  - » Time-dependent factors defined using standard functions or tables and local delays
  - » Definition of any dynamic load, including ground displacement, moving loads, etc.
- Free Response Analysis
  - » Eigenvalues and eigenvectors using linear or tangential structural stiffness
  - » Calculation of modal participation factors
  - » Natural modes are stored as separate loading cases
- Response Spectrum Analysis
  - » Response spectrum defined as a table in terms of displacement, velocity, or acceleration
  - » Individual results combined using stochastic superposition rules:
    - ABS rule - Total response by combining the absolute values of all the individual contributions
    - SRSS rule - Natural modes are completely uncorrelated (superposition in Pythagorean manner)
    - DSC rule - Correlation between the contributions of the individual natural modes
    - CQC rule - Models the correlation between multiple different modes using absolute values
    - CQCX rule - Variation of the CQC rule in which the natural modes are combined as in CQC and the sign of the modes is considered
- Result envelopes for internal forces and displacements

### Time History Analysis

- Time stepping with consideration of nonlinear materials, geometry, springs, and dampers
- Time-dependent loads
- Time-dependent masses
- Structural response related to a specified dynamic load using linear or tangent structural stiffness
- Response values in time for elements and nodes
- Result envelopes for internal forces and displacements
- Graphic presentation of results

### Stability Analysis

- Linear buckling behavior with stiffness matrix based on second-order theory rules
- Accounts for imperfections by defining fabrication shapes consistent with support conditions or by taking over factorized deformation shapes due to static load cases or critical buckling modes
- Allows for the application of local prescribed deformations (overlaps, local strains), canceling the related internal constraint forces
- Consideration for nonlinear buckling

### Reinforced Concrete Design

- Calculation of reinforcement for concrete sections, or additionally required reinforcement for prestressed sections
- Uses plastic design principles to handle any cross section shape and any combination of biaxial bending and axial force
- Handles 2D and 3D cases consisting of normal force plus axial or biaxial bending
- Graphic presentation of the biaxial bending and axial forces interaction

### Prestressed Concrete (Pre-and Post-Tensioned)

- Construction Stages
  - » Consideration of different construction stages by activating parts of the completely defined structure
  - » Individual tendon stressing in different stages
  - » Calculation of losses due to time effects and other prestressing actions
  - » Automatic updating of cross section characteristics (duct area, tendon area, grouting)
  - » Accounts for cross-sectional changes in the computation of eccentricity of individual cables
- Tendon Geometry and Prestressing Force Distribution
  - » Interactively define cable geometry for calculating prestressing force distribution
  - » Calculates prestressing force distribution by accounting for friction losses caused by the spatial curvature
  - » Stressing on both ends of cable, releases, and wedge slips are available
  - » Computes cable lengths and elastic cable extensions
  - » Automatically checks final cable positions in a single section (distance between cables; distance between cables and surface of girder; placement where two cables cross in the horizontal plane)

- Load Case Prestressing
  - » Determines the initial strains and stresses (primary effects) from the cable geometry and prestressing force distribution
  - » Accounts for axial force, biaxial bending, and torsion effects
  - » Applies computed fixed-end-forces as a load to the structural system
  - » Outputs total displacements and internal forces (secondary effects)
- Load Case Creep/Shrinkage and Steel Relaxation
  - » Time-dependent analysis using a finite difference scheme
  - » Calculation of all creep and shrinkage coefficients depending on the design code
  - » Factors percentage of the total relaxation occurring in each time step
  - » Automatic calculation of primary and secondary effects

### Steel Structures

- Standard or user-defined geometry for section shapes
- Calculates characteristics of thin-walled cross sections (open or closed-shape sections)
- Calculates cross section properties, including shear center and warping coefficients
- Automatically computes all fiber and shear stresses in addition to internal forces
- Force results from individual and/or combined load cases
- Buckling check for bending with compression normal force
- Steel structure nonlinear behavior considerations

### Composite Structures

- Composite sections could be defined with different types of concrete (quality or age) or concrete with steel
- Allows for modification of the structural system and/or cross section during the construction sequence
- Option to load individual parts before combining into a composite section
- Combines stresses from loading individual parts prior to a composite creation
- Calculates results for individual section parts or the composite section
- Post-processing functions (design code checks, graphics, etc.) performed for individual section parts or the composite section
- Prestressing and creep and shrinkage calculations for each cross section part
- Construction-stage features for composite and individual elements

## SYSTEM REQUIREMENTS

### Processor:

Intel Pentium or AMD AthlonT

### Operating System:

Windows Vista, XP, and 2000

### RAM:

256MB minimum, 512MB recommended

### Hard Disk:

900MB free disk space (includes the 400MB install footprint for a complete installation)

### Display:

Graphics Card supported by DirectX 9.0

## ABOUT BENTLEY

Bentley Systems, Incorporated is the global leader dedicated to providing comprehensive software solutions for sustaining infrastructure. Architects, engineers, constructors, and owner-operators are indispensable in improving our world and our quality of life; the company's mission is to improve the performance of their projects and of the assets they design, build, and operate. Bentley sustains the infrastructure professions by helping to leverage information technology, learning, best practices, and global collaboration – and by promoting careers devoted to this crucial work.

For more information, visit [www.bentley.com](http://www.bentley.com)

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- Specific composite features available: shear stud design, force redistribution from the cracked part to the remaining part
- Prestressed and post-tensioned concrete features for composite construction

### Design Code Checks

- Design code check for AASHTO LRFD and LFD
- Support for 20 international design codes
  - » AASHTO 1996 based on CEB-FIP 90
  - » Australian Standard AS5100
  - » Austrian Standard OENORM B4750
  - » British standard BS5400
  - » Chinese Highway Code JTG D62
  - » Eurocode 2
  - » Finnish Standard
  - » French Standard
  - » German Standard DIN1045/1 (2002)
  - » German Standard FB102
  - » Hong Kong Standard based on BS5400
  - » Hungarian Standard HUNG-UT2/13
  - » Indian Standard IRC
  - » Korean Standard
  - » Load and resistance factor design (American code) – LRFD 2007
  - » New Zealand Standard - NZS 3101
  - » Norwegian NS3473 Standard
  - » Portugal Standard
  - » Spanish Standard EHE
  - » Swedish Standard

- Design code checks could be performed during individual construction stages
- Fiber stress checks
- Shear capacity checks
- Ultimate load carrying capacity checks
- User-defined cross-section cuts (web, slab, cantilever plate, etc.) for shear stresses (shear forces) checks
- Crack-width checks for reinforced sections
- Robustness check for prestressed (pre and post-tensioned) sections
- Fatigue checks for structures subject to cyclic loading
- Automatic notation of points where design values exceed resistance values
- Graphical presentation of all design code check results
- Automatically calculates the required reinforcement in pre-defined layers
- Automatically calculates bidirectional shear force and torsional moment distribution over the relevant cross section

### Construction Engineering

- Construction sequence simulation
- Automatic camber calculation depending on the erection control technique
- Allows for temporary construction elements

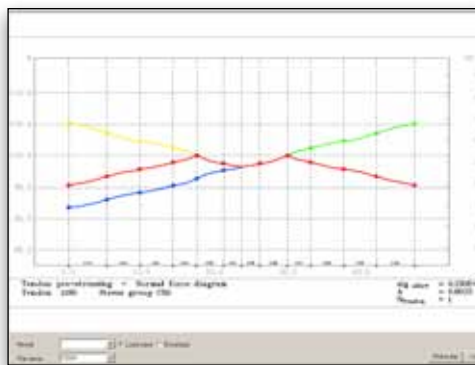
- Predefines unloaded lengths of cables and girder elements with total elastic distortion and elongation
- Simulates the distribution of construction stage forces
- Ensures that the final structure is in the correct position in space
- Results are accessed after any stage as an intermediate result or as an accumulated result of previous stages

### Plans Production

- Automatic generation of design and construction CADD drawings
- User-defined templates for drawing generation
- Generation of CADD section drawings for rebar detailing
- Powerful Drawing Manager keeps track of generated files
- Automatically links generated drawings, allowing for easy navigation

### Data Exchange

- CADD data exchange with MicroStation DGN and LandXML formats
- Data exchange with Bentley InRoads, GEOPAK, Bentley MXROAD, and Bentley Rail software systems
- Data exchange with Bentley ProjectWise® Navigator
- Data export to Microsoft Office products
- Data export to AutoCAD



Cable force diagram after stressing/relaxing/wedge slip, including friction losses.

The figure shows a screenshot of an Excel spreadsheet with multiple columns and rows of numerical data. The data appears to be organized into sections, likely representing different spans or construction stages, with columns for various parameters and calculated values.

Camber calculations are done automatically and delivered in an Excel sheet.