

TAIWAN HIGH SPEED RAIL PROJECT TAIPEI, TAIWAN	YEAR COMPLETED	
	PROFESSIONAL SERVICES 1998 – 2007	RIZZO CONTRACT
PROJECT OWNER'S INFORMATION		
a. PROJECT OWNER Provisional Engineering Office of High Speed Rail, Ministry of Transportation and Communications	b. POINT OF CONTACT NAME Dr. Jeder Hsieh	c. TELEPHONE NUMBER (886-2) 349-5843

RIZZO Associates acquired International Civil Engineering Consultants, Inc. (ICEC) in March 2007, and became part of RIZZO a global engineering and consulting firm headquartered in Pittsburgh, Pennsylvania. This project was completed under ICEC.

Key personnel from RIZZO, as employees of the legacy firm ICEC, performed several expert seismic evaluations in conjunction with this project including: conducting structural vibration studies to develop vibration criteria for aerial structures planned for the Taiwan High-Speed Rail Project. These studies included performing dynamic response analyses of the standard aerial structural designs under moving train loadings (up to 350 km/hour speed) and developing impact factors for structural designs. Parameters considered in these studies included (1) structural types, 3-4 continuous span with constant or variable span lengths; (2) train loading type; (3) ballasted vs. unballasted decks; (4) structural frequency variations; (5) straight and curve alignments; and (6) train speeds varying from 0 to 350 km/hr. RIZZO's Dr. Joseph Penzien was contracted to serve as a member of the seismic consultant panel to the Taiwan High-Speed Rail Project giving expert advice on (a) development of seismic ground motions for the project and (b) development of seismic design criteria for the aerial structures, tunnels, bridges, and station structures.



A Typical Elevated Structure for THSR

RIZZO personnel conducted a study on seismic performance evaluations of the various alternative structural systems under consideration by Provisional Engineering Office of High Speed Rail (PEOHSR). This work was divided into four tasks as follows: (1) generation of three components (x, y, and z) of response-spectrum-compatible control motions (acceleration time histories) for each of four site conditions (S1, S2, S3, and S4) representing the design seismic conditions at a fixed point, (2) development of multiple 3-component sets of response-spectrum-compatible motions from each set of control motions which reflect realistic spatial variations in the ground motions so that they can be used for the multiple-support dynamic inputs to the elevated structural systems, (3) evaluation of the linear dynamic response of selected structural systems, having variable column lengths, to the multiple input motions generated in Task No. 2 with the objective of estimating track misalignments at expansion joints in the deck which can be used in judging safety of train operation, and (4) performing nonlinear time-history response evaluations of selected structural systems to the design seismic inputs to assess structural performance and safety.

RIZZO personnel determined the dynamic response characteristics of standard-design elevated structures subjected to moving train loads associated with the each of the three types (French TGV, German ICE, Japanese SKS) of high speed trains. The dynamic response results generated by this study were used to (1) evaluate suitable structural design from the perspective of vibration performance under the moving train loads; and (2) the determination of appropriate dynamic load impact factors to be used for detail designs of the structures.



THSR Taichung Station

RIZZO personnel were contracted to perform structural vibration assessment of the Taoyuan Station for Taiwan High Speed Rail. The scope of work consisted of (1) to determine the characteristics and amplitudes of structural vibration induced in various locations of the station structures and (2) to evaluate whether such vibration amplitudes will satisfy the vibration acceptance criteria.

We were also contracted to perform structural vibration assessment of the Taichung Station for Taiwan High Speed Rail. The objective of these analyses was to evaluate the effects on the train-induced station-structure vibration and structure-borne noise as a result of a modification in trackform construction in Taichang Station. Assessments of the dynamic response of the lead-lined ceilings and structure-borne noise generated in the station by the train induced structural vibrations were also performed.



## TAIWAN HIGH SPEED RAIL PROJECT

RIZZO personnel were contracted by the National Science Council (Republic of China) to evaluate ground vibrations in Tainan Science-Based Industrial Park induced by Taiwan High Speed Rail Train Operation. The scope of work for this investigation covered the evaluation of free-field ground vibrations in TSIP, with appropriate consideration of the specific THSR trainset make-up, train speed, train-supported elevated structures, and foundation configurations. ICEC was also involved for verifying the technical validity and numerical accuracy of the analyses performed by Sheus Technologies Corporation and also developed "Composite vibration-reduction construction method" for application to the Industrial Park.

In addition, RIZZO was contracted to perform independent verification and validation (IV&V) for the TSIP ground vibration mitigation project by Southern Taiwan Science Industrial Park Administration (STSIPA).

Overall scope of work consisted of: (1) Assist STSIPA in selection of vibration measurement locations inside and outside of TSIP, (2) Perform analysis, comparison, and assessment of free-field ground vibration data acquired from instruments, (3) Compare measured free-field ground vibration obtained from (2) with predicted target and measured ambient ground vibration levels, and (4) Evaluate effectiveness of ground vibration mitigation measures constructed in TSIP.



### Summary of Services Provided:

- Development of Ground Motions and Aerial Structural Models.
- Dynamic and Seismic Response Analyses.
- Vibration of Elevated Bridge Structures caused by High Speed Train Loadings .
- Vibration Measurements & Verification at TSIP.
- Train-Induced Structural Vibration Assessment.
- Train-Structure Interaction Dynamic Response Analyses of Aerial Guideway Structures in Tainan Science-Based Industrial Park.
- Evaluation of Ground Vibrations in Tainan Science-Based Industrial Park.
- Taoyuan Station, Design Development Phase, Station Structure Vibration Assessment.
- Taichung Station, Station Structure Vibration Assessment induced by high-speed rail passing through the station.
- Southern Taiwan Science Industrial Park Administration (STSIPA), Independent Verification and Validation of Dynamic Analyses of Train-Induced Free-Field Ground Vibrations at TSIP.

