VecTor5 (Frame Analysis)

VecTor5 is a nonlinear modeling software for the analysis of plane frames consisting of beams, columns and shear walls, subjected to quasi-static (monotonic, cyclic and reversed-cyclic). dynamic (seismic, impact and blast), and thermal loads. Pre-processor **FormWorks+** allows users to create their analysis models in a graphical environment, while program **Janus** displays the analysis results in a user-friendly manner including deflected shapes, crack patterns, concrete and rebar stresses, failure modes, and so on.

VecTor5 is extensively validated with large-scale experimental tests. 13 journal papers are published, summarizing the results – see the next page. Considering 151 large-scale experimental specimen simulations, an average of 1.00 and a coefficient of variation of 11.6% is achieved for the predicted-to-experimental nominal strength ratios.

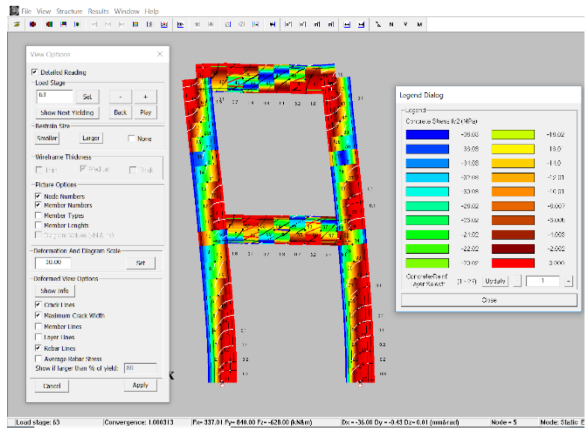
VecTor5 allows the analysis of frames with unusual or complex cross-sections and considers many second-order mechanisms to accurately represent the behaviour of cracked concrete. The compression softening due to transverse cracking, tension stiffening, shear slip along crack surfaces and out-of-plane confinement and expansion effects are explicitly considered. Displacement-controlled mode allows an analysis to continue after the peak, capturing the post-peak response and the displacement ductility.

The deep beam element (Liu et al. 2019) allows combining traditional frame elements with deep beam elements to account for failures and post-peak behaviors associated with complex shear failures. The deep beam element uses a three-parameter kinematic model (Liu and Mihaylov 2018) based on the behavior of two fans and a critical shear crack.

The default RDM material model (Akkaya et al. 2019) enables capturing the buckling response of reinforcing bars in concrete members while accounting for the interactions between the lateral ties and longitudinal bars. This model is capable of simulating the onset of inelastic buckling and subsequent degradation in the post-buckling region.

VecTor5 employs a distributed-plasticity, layered section approach, and an iterative, total-load, secant-stiffness formulation. The nonlinear sectional analyses provide a comprehensive and accurate representation of the concrete response, including the shear effects coupled with axial and flexural responses based on the Modified Compression Field Theory (Vecchio and Collins 1986) and the Disturbed Stress Field Model (Vecchio 2000).

Nonlinear dynamic analysis algorithms employ an explicit three-parameter time integration method, allowing the use of Newmark's average or linear acceleration, or Wilson's theta methods. The effects of high strain rates on the material behavior are accounted for. Structural damping is provided by the nonlinear concrete and reinforcement hysteresis models (Guner and Vecchio 2011).



Sample Analysis Results Displayed by Janus

	Premium	Basic*
Capacities		
Frame Members	2,000	10
Nodes	2,000	10
Members Types	50	2
Concrete Layers	110	20
Reinforcement Layers	50	3
Material Types		
Concrete layers	✔	✔
Steel bars (truss bar or smeared)	✔	✔
Deep beam elements (monotonic load)	✔	
Reinforcement Material Types		
Steel, Prestressing Steel	✔	✔
Load Types		
Static Forces	✔	✔
Static Displacements	✔	✔
Prestrains	✔	✔
Impact & Blast Forces	✔	
Ground Accelerations	✔	
Thermal / Heat Flow	✔	
Analysis Modes		
Static Nonlinear – Load Step	✔	✔
Static Nonlinear – Time Step	✔	
Dynamic Nonlinear – General	✔	
Dynamic Nonlinear – EQ Record	✔	
Dynamic Nonlinear – Impulse	✔	
Material Models		
Full Range of Models	✔	
Default Models Only		✔

**Basic version not to be used for commercial purposes*

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Journal Papers

Guner, S., Hrynyk, T. D., and Lulec, A. "Cracked Continuum Modeling of Reinforced Concrete Elements under Impact," High Strain Rate Mechanics and Impact Behavior of Concrete, High Strain Rate Mechanics and Impact Behavior of Concrete, American Concrete Institute, SP-347(5): 85-105. <download>

Liu, J., Guner, S., and Mihaylov, B. (2019) "Mixed-Type Modeling of Structures with Slender and Deep Beam Elements" ACI Structural Journal, 116(4): 253-264. <download>

Akkaya, Y., Guner, S. and Vecchio, F. J. (2019) "A Constitutive Model for the Inelastic Buckling Behavior of Reinforcing Bars," *ACI Structural Journal*, 116(3): 195-204 <download>

Salgado, R. and Guner S. (2018) "A Comparative Study on Nonlinear Models for Performance-Based Earthquake Engineering," *Engineering Structures*, 172: 382-391 <download>

Peng, C. and Guner, S. (2018) "Direct Displacement-Based Seismic Assessment of Concrete Frames Using Nonlinear Pushover Analysis," *Computers and Concrete*, 21(4): 355-365 <download>

Pan, Z., Guner, S. and Vecchio, F. J. (2017) "Modeling of interior beam-column joints for nonlinear analysis of reinforced concrete frames," *Engineering Structures*, 142: 182-19 <download>

Guner, S. (2016) "Simplified Modeling of Frame Elements subjected to Blast Loads," *ACI Structural Journal*, 113(2): 363-372 <download>

Guner, S. and Vecchio, F. J. (2012) "Simplified Method for Nonlinear Dynamic Analysis of Shear-Critical Frames," *ACI Structural Journal*, 109(5): 727-737 <download>

Guner, S. and Vecchio, F. J. (2011) "Analysis of Shear-Critical Reinforced Concrete Plane Frame Elements under Cyclic Loading," *Journal of Structural Engineering*, ASCE, 137(8): 834-843 <download>

Guner, S. and Vecchio, F. J. (2010b) "Pushover Analysis of Shear-Critical Frames: Verification and Application," *ACI Structural Journal*, V.107(1): 72-81 <download>

Guner, S. and Vecchio, F. J. (2010a) "Pushover Analysis of Shear-Critical Frames: Formulation," *ACI Structural Journal*, 107(1): 63-71 <download>

Vecchio F. J. and M.P. Collins (1988) "Predicting the Response of Reinforced Concrete Beams Subjected to Shear using the Modified Compression Field Theory," *ACI Structural Journal,* 85: 258-268 <download>

Vecchio F. J. (1987) "Nonlinear Analysis of RC Frames Subjected to Thermal and Mechanical Loads," *ACI Structural Journal,* 84(6): 492-501 <download>

User Manuals

Blosser, K., Guner, S., and F. J. Vecchio (2016) "User's Manual of FormWorks Plus for VecTor5," 29 pp. <download>

Loya, A.S., Lourenço, D.D.S, Guner, S., Vecchio, F.J. (2015) "User's Manual of Janus for VecTor5," 28 pp. <down>

Guner, S. and Vecchio, F. J. (2008) "User's Manual of VecTor5," 88 pp. <download>

Reports

Liu, J., Guner, S., and Mihaylov, B. (2021) "A New Deep-Beam Element for Mixed-Type Modeling of Concrete Structures," Project report, 31 pp. <download>

User Bulletins

Liu, J., Guner, S., and Mihaylov, B. (2021) "User Bulletin 8: Deep Beam Modeling with VecTor5," 3 pp. <download>

Coffman, A., Guner, S. (2019), "Bulletin 6: Frame Modeling with VecTor5 using Pre-Processing," 15 pp. <download>

Chu, P., Guner, S. (2016) "Bulletin 5: Determination of Material Properties," 11 pp. <download>

Blosser, K., Guner, S. (2016) "Bulletin 4: Beam Modeling with VecTor5 using Pre-and Post-Processing," 14 pp <dw>

Salgado, R. and Guner, S. (2014) "Bulletin 3: Determination of Unsupported Length Ratio L/Db," 11 pp. <download>

Viana, H. F. and Guner, S. (2014) "Bulletin 2: Frame Modeling with VecTor5," 16 pp. <download>

Viana, H. F. and Guner, S. (2014) "Bulletin 1: Beam Modeling with VecTor5," 20 pp. <download>

Videos

Blosser, K. and Guner, S. (2016)
- Video 1: Setup for Nonlinear Analysis (4:25)
- Video 2: Beam Modeling (18.22)
- Video 3: Obtaining Analysis Results (7:01)
- Video 4: Frame Modeling (26:57)

See Dr. Guner's YouTube channel for these and other videos: www.youtube.com/c/SerhanGuner