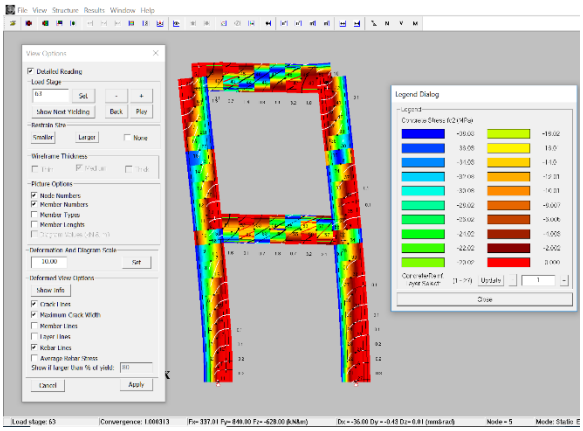
VecTor5 is a nonlinear finite element analysis program for two-dimensional frame structures consisting of beams, columns and shear walls, subjected to thermal, quasi-static (monotonic, cyclic and reversed-cyclic) and dynamic (seismic, impact and blast) loads. Auxiliary program **FormWorks+** allows users to create their analysis models in a graphical environment, while program **Janus** displays the analysis results including deflected shapes, crack patterns, concrete and rebar stress contours, failure modes, and so on.

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

The incorporated deep beam element (Liu et al. 2019) allows combining slender frame and 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 & Mihaylov 2018), based on the behavior of two fans (modeled by rotational springs) and a critical shear crack (modelled by a transverse spring).

The included buckling model (Akkaya et al. 2019) enables capturing the buckling response of compression 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 six-degree-of-freedom fiber-section elements using a distributed-inelasticity algorithm, 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 & Collins 1986) and the Disturbed Stress Field Model (Vecchio 2000). Compression-only, tension-only, and truss elements are also available to model various conditions (e.g., special supports, soil, brace elements, etc.).



Sample Analysis Results Displayed by Janus

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 & Vecchio 2011).

	Full	**Basic**
Capacities:		
Frame Members	2,000	100
Nodes	2,000	100
Members Types	50	10
Concrete Layers	110	30
Reinforcement Layers	50	5
Continuum Material Types:		
Concrete	✓	✓
Steel	✓	✓
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		✓

Journal Papers

Salgado, R. & Guner, S. (2019) "A Numerical Analysis Methodology for Deep Cap Beams Retrofitted with Fiber Reinforced Polymers," *Advances in Concrete Bridges*, American Concrete Institute (accepted)

Liu, J., Guner, S. & Mihaylov B. (2019) "Mixed-Type Modeling of Structures with Slender and Deep Beam Elements," ACI Structural Journal (accepted)

Akkaya, Y., Guner, S. & Vecchio, F. J. (2019) "A Constitutive Model for the Inelastic Buckling Behavior of Reinforcing Bars," *ACI Structural Journal*, V.116, No.3, pp. 195-204 <download>

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

Peng, C. & Guner, S. (2018) "Direct Displacement-Based Seismic Assessment of Concrete Frames Using Nonlinear Pushover Analysis," *Computers and Concrete*, V.21, No.4, pp.355-365 <download>

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

Guner, S. (2016) "Simplified Modeling of Frame Elements subjected to Blast Loads," *ACI Structural Journal*, V.113, No.2, pp. 363-372 <download>

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Guner, S. & Vecchio, F. J. (2011) "Analysis of Shear-Critical Reinforced Concrete Plane Frame Elements under Cyclic Loading," *Journal of Structural Engineering*, ASCE, V.137, No.8, pp. 834-843 <download>

Guner, S. & Vecchio, F. J. (2010b) "Pushover Analysis of Shear-Critical Frames: Verification and Application," *ACI Structural Journal*, V.107, No.1, pp. 72-81 <download>

Guner, S. & Vecchio, F. J. (2010a) "Pushover Analysis of Shear-Critical Frames: Formulation," *ACI Structural Journal*, V.107, No.1, pp. 63-71 <download>

User Manuals

Blosser, K., Guner, S., & 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. <download>

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

User Bulletins

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

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

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

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

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

Videos

Blosser, K. & 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)

Posted at www.youtube.com/user/gunerser