ASSESSMENT OF PROGRESSIVE COLLAPSE CAPACITY OF DUAL STEEL CONCENTRICALLY BRACED FRAMES WITH SEMI-RIGID CONNECTION

By

Abdullah Mohammed Mahmoud AL-Saied AL-Falahgy

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
Structural Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
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Under the Supervision of

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Title of Thesis:

Assessment Of Progressive Collapse Capacity Of Dual Steel Concentrically Braced Frames With Semi-Rigid Connection

Key Words:

Progressive Collapse; Steel Bracing Moment Resisting Frame; Spring Component Model; Rigid connection; Semi-Rigid Connection; Extended End-Plate; Linear Time-History Analysis.

Summary:

This research investigates progressive collapse phenomena of steel braced frames (dual system) with semi-rigid connections assigned at beam-column joints, due to abnormal loading events. This phenomena occurs when one or more of major structural members cannot resist over loads due to sudden removal of structural elements. Two dimensional (2-D) analytical models are created using a commercial computer program SAP2000 and designed according to American Society of civil engineers (ASCE, 7-05). And followed by progressive collapse procedures due to General Service Administration (GSA, 2003). Linear static analysis and linear time history analysis were carried out for progressive collapse evaluation using semi-rigid connection definition at beam to column joints. A variety of structural models are analyzed for progressive collapse conditions using variable definition of structural models. These parameters are defined variously for number of stories, story height, span length and number of bays with different locations of removed members. The results are investigated according to structural members demand capacity ratio (DCR), vertical displacement upon point of column removal and lateral story drift. Effectiveness of semi-rigid connection was investigated and compared with results using fully-rigid connections.

DISCLAIMER

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sourced used and have cited them in the references section.

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Date: …./…./2019

Signature:

DEDICATION

I dedicate this research to my parents. I am forever indebted to them for their understanding, endless patience, encouragement, support, and sacrifice when it was most required. I largely owe all I have achieved and aspire to achieve in my life. It would have been impossible to accomplish this study without their guidance, loving support and constant motivational encouragement.

Abdullah Mohammed Mahmoud

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Secondly, a big thanks go to my brothers, who unceasingly supported me in the best possible way during the whole period of this study.

Finally, I dedicate this research to my parents. I am forever indebted to them for their understanding, endless patience, encouragement, support, and sacrifice when it was most required. I largely owe all I have achieved and aspire to achieve in my life. It would have been impossible to accomplish this study without their guidance, loving support and constant motivational encouragement.

Author

Abdullah Mohammed Mahmoud

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List of Abbreviations

AISC	American Institute of Steel Construction
ASCE	American Society of Civil Engineers
ASD	Allowable strength design
AU	Stress area of upper row bolts
AL	Stress area of lower row bolts
Aw	Weld area of flange and web
Ab	Cross-sectional area of the bolt
Ac	Cross-sectional area of the column
Bbf	Beam flange width
B_{plate}	End-plate width
CP	Pressure coefficient
Cd	Deflection amplification factor
Ct	Approximate period parameters
Db	Bolt diameter
d_b	Depth of beam web
DL	Dead loads
DCR	Demand Capacity Ratio
ECP	Egyptian Code of Practice
E	Young’s modulus of steel
Er	Young’s modulus of rigid link
FEMA	Federal Emergency Management Agency
Fy	Yield Stresses
Fu	Ultimate Tensile Stresses
Fye	Effective Yield Stresses
Fue	Effective Tensile Stresses
Fpw	Allowable stress of fillet weld
FtA	Stress at point (A)
FtB	Stress at point (B)
Fb	Allowable bending stress of end plate
fU	Upper row bolt stress
fL	Lower row bolt stress
G	Gust factor
GSA	Genera Service Administration
GN	Gravity loads for linear static analysis
GND	Gravity loads for dynamic linear time history analysis
HSS-sec	Box-Sections
htb	Total depth of beam
htc	Total depth of the column
h_b	Depth of the beam web
hc	Depth of the column web
I	Importance factor
IBC	International Building Code
Ipx	End plate moment of inertia
Iwx	Weld moment of inertia about X-axis
Ic	Column moment of inertia
Ib	Beam moment of inertia
Kep	Spring stiffness of end plate due to flexure stress
Kcf	Spring stiffness of column flange due to flexure stress
Kcwc	Spring stiffness of column web due to compression stress
Kcwt	Spring stiffness of column web due to tension stress
Kcwv	Spring stiffness of column web due to shear of panel zone stress
Kbp	Spring stiffness of bolts due to tension stress
Kd	Wind directional factor
Kz	Exposure coefficient

Kzt	Topographic factor
L	Distance between the two upper bolts rows
LL	Live Loads
Lfw	Length of flange weld
Lww	Length of web weld
L_{plate}	End-plate length
Lbo	Length of the bolt
LF	Load Factor
Lc	Column Height
Lb	Beam Length
M	Beam end moment
Mp	Binding moment in end plate
mc	Distance from the center of the bolt hole to the column web
mep	Distance from the center of the bolt hole in the upside to the upper surface of beam flange
N	Beam normal force
nep	Distance from the center of the bolt hole in the upside to the upper edge of end-plate
nc	Distance from the center of the bolt hole to the nearest edge of column flange
Q	End beam shear force
qz	Wind pressure
R	Response modification coefficient
r_c	Column root radius
r_b	Beam root radius
S	Weld thickness
Sbf	Weld thickness of beam flange
Sbw	Weld thickness of beam web
Tf	Tension in upper beam flange
Tb(M)	Bolt tension force due to beam end moment
Tb(N)	Bolt tension force due to beam normal force
tbw	Thickness of beam web
tbf	Thickness of beam flange
tep	End-plate thickness
tcf	Thickness of column flange
tcw	Thickness of column web
t_{eb}	End-plate thickness
UFC	Unified Facilities Criteria
USA	United States of America
V	Wind speed
W	Wind Loads
$W_{D.L.}$	Distributed Dead Loads
$W_{L.L.}$	Distributed Live Loads
W-sec	Wide flange-Sections
Ω	Over strength factor
ΩNS	Dynamic increase (amplification) factor for linear static analysis
p	Distance between the centers of the bolt hole at the same horizontal line
μ	Poisson's ratio for steel
θ	Chord rotation
υ	Poison’s ratio
2-D	Two-dimensional model
3-D	Three-dimensional model