Occasional Paper on

Shape Modification of the Insulated Rail Joint Bar

Central Queensland University
Rockhampton, Queensland, Australia

November 2007

A/Prof. Mohammad Hossein Abolbashari

Mechanical Engineering Department, Ferdowsi University of Mashhad
PO Box 91775-1111, Mashhad, Iran
abolbash@um.ac.ir

Visiting Scholar, Centre for Railway Engineering

CQU - LIBRARY
1001448941

CENTRE
FOR RAILWAY ENGINEERING
Customer focused research and training

625.15
5
Rockhampton

Occasional Paper on

Shape Modification of the Insulated Rail Joint Bar

Central Queensland University
Rockhampton, Queensland, Australia

November 2007

A/Prof. Mohammad Hossein Abolbashari

Mechanical Engineering Department, Ferdowsi University of Mashhad
PO Box 91775-1111, Mashhad, Iran
abolbash@um.ac.ir

Visiting Scholar, Centre for Railway Engineering

CENTRE
FOR RAILWAY ENGINEERING
Customer focused research and training

CENTRAL QUEENSLAND
UNIVERSITY - LIBRARY

Copyright © Mohammad Abolbashari reserves all rights.

Published in 2007

ISBN : 1 921047 54 2

Published by:

CQU Publishing Unit
Bruce Highway, North Rockhampton, Australia 4702

PREFACE

Insulated rail joints are important safety critical sections in the rail track network. These joints are used for signalling purposes and train identification. Unfortunately, these joints fail relatively early and possess approximately 20% of the life of the continuously welded rails. Therefore, study of the behaviour of these joints has recently become the focus of a number of rail researchers around the world.

The current design of insulated rail joints resembles bolted butt joints, in which the bolts are pre-tensioned. The entire joint assembly is fabricated in factories, involving two cycles of heat treatment. These joints are removed from service when the joint bars fail due to cracking. Therefore a more refined study of the failure of joint bars is essential.

The work by Prof. Abolbashari as a visiting scholar to the Centre for Railway Engineering at Central Queensland University has focused on joint bar analysis. This report summarises his work presented to the Centre members.

22nd October 2007

A/Prof. M. Dhanasekar (Sekar) PhD, RPEQ,
Associate Professor of Engineering Infrastructure,
Director - Centre for Railway Engineering,
Central Queensland University,
Rockhampton, QLD 4702, Australia.
Ph. +61 7 4930 9677; Fax. +61 7 4930 6984
Email: m.dhanasekar@cqu.edu.au
http://www.cre.cqu.edu.au

Table of Contents

Shape Modification of the Insulated Rail Joint Bar v
Abstract v
Table of Contents vi
List of Figures vii
List of Tables viii
Acknowledgements ix
Shape Modification of the Insulated Rail Joint Bar 1
1. Introduction 1
1.1. Literature Review 2
1.2. Insulated Rail Joint Bar Assembly 2
2. Finite Element Analysis of Joint Bar 3
2.1. Geometry 3
2.2. Loading and Boundary Conditions 5
2.2.1. Case L 1 6
2.2.2. Case L 2 10
2.2.3. Case L 3 14
2.2.4. Case L 4 16
2.2.5. Case L 5 19
2.2.6. Case L 6 21
2.2.7. Case L 7 22
2.2.8. Case L 8 23
2.2.9. Case L 9 25
3. Modification 28
3.1. Case Opt 1 29
3.2. Case Opt 2 30
3.3. Case Opt 3 31
3.4. Case Opt 4 32
3.5. Case Opt 5 33
3.6. Case Opt 6 34
3.7. Case Opt 7 35
3.8. Case Opt 8 36
3.9. Case Opt 9 38
3.10. Case Opt 10 39
3.11. Summary of the Results 40
4. Conclusion 43
5. Future Work 43
6. References 43

List of Figures

Figure 1: A typical 4-bolt insulated rail joint 1
Figure 2: A typical 4-bolt insulated rail joint bar assembly 2
Figure 3: The 60 kg rail cross section dimensions [9] 3
Figure 4: Rail joint assembly cross section [10] 4
Figure 5: 3D geometry of the joint bar with some partitions 4
Figure 6: Geometry of the cross section of the joint bar (Dimensions in mm) 4
Figure 7: Front view of the 4-bolt joint bar (Dimensions in mm) 5
Figure 8: The rail with two joint bars model of Case L 1 7
Figure 9: von Mises stress contours of the model shown in Figure 8 7
Figure 10: von Mises stress contours of the front joint bar of model shown in Figure 8 8
Figure 11: Contours of normal stress in the z-direction of the front joint bar of model shown in Figure 8 8
Figure 12: Displacement in x-direction of front joint bar of model shown in Figure 8 9
Figure 13: Displacement in y-direction of front joint bar of model shown in Figure 8 9
Figure 14: Displacement in z-direction of front joint bar of model shown in Figure 8 9
Figure 15: Loading and boundary conditions of the joint bar of Case L 2 10
Figure 16: Contours of normal stress in the z-direction of joint bar model shown in Figure 15 11
Figure 17: von Mises stress contours of the joint bar model shown in Figure 15 11
Figure 18: Displacement in the x-direction of the joint bar model shown in Figure 15 12
Figure 19: Displacement in the y-direction of the joint bar model shown in Figure 15 12
Figure 20: Displacement in the z-direction of the joint bar model shown in Figure 15 13
Figure 21: Loading and boundary conditions of the joint bar of Case L 3 14
Figure 22: Contours of normal stress in the z-direction of joint bar model shown in Figure 21 15
Figure 23: von Mises stress contours of the joint bar model shown in Figure 21 15
Figure 24: Loading and boundary conditions of the joint bar of Case L 4 16
Figure 25: Contours of normal stress in the z-direction of the joint bar model shown in Figure 24 17
Figure 26: von Mises stress contours of the joint bar model shown in Figure 24 17
Figure 27: Loading and boundary conditions of the joint bar of Case L 5 19
Figure 28: von Mises stress contours of the joint bar model shown in Figure 27 20
Figure 29: Vertical displacement contours of the joint bar model shown in Figure 27 20
Figure 30: Boundary conditions of the joint bar of Case L 6 21
Figure 31: von Mises stress contours of the joint bar model with boundary conditions shown in Figure 30 21
Figure 32: Loading and boundary conditions of the joint bar of Case L 7 22
Figure 33: von Mises stress contours of the joint bar model shown in Figure 32 22
Figure 34: Loading and boundary conditions of the joint bar of Case L 8 23
Figure 35: von Mises stress contours of the joint bar model shown in Figure 34 24
Figure 36: Cross section of the joint bar of Case L 9 25
Figure 37: von Mises stress contours of the joint bar model with cross section shown in Figure 36 and pressure load of 18 MPa 26
Figure 38: von Mises stress contours of the joint bar model with cross section shown in Figure 36 and pressure load of 18.95 MPa 27
Figure 39: Loading and boundary conditions of the joint bar of Case Opt 1 29
Figure 40: von Mises stress contours of the joint bar model shown in Figure 39 29

Figure 41: Loading and boundary conditions of the joint bar of Case Opt 2 30
Figure 42: von Mises stress contours of the joint bar model shown in Figure 41 30
Figure 43: Loading and boundary conditions of the joint bar of Case Opt 3 31
Figure 44: von Mises stress contours of the joint bar model shown in Figure 43 31
Figure 45: Cross section of the joint bar of the Case Opt 4 32
Figure 46: von Mises stress contours of the joint bar model with cross section shown in Figure 45 32
Figure 47: Cross section of the joint bar of the Case Opt 5 33
Figure 48: von Mises stress contours of the joint bar model with cross section shown in Figure 47 33
Figure 49: Cross section of the joint bar of the Case Opt 6 34
Figure 50: von Mises stress contours of the joint bar model with cross section shown in Figure 49 34
Figure 51: Cross section of the joint bar of the Case Opt 7 35
Figure 52: von Mises stress contours of the joint bar model with cross section shown in Figure 51 35
Figure 53: Cross section of the joint bar of the Case Opt 8 36
Figure 54: von Mises stress contours of the joint bar model with cross section shown in Figure 53 36
Figure 55: von Mises stress contours of the interior of the side holes of the Case Opt 8 37
Figure 56: Cross section of the joint bar of the Case Opt 9 38
Figure 57: von Mises stress contours of the joint bar model with cross section shown in Figure 56 38
Figure 58: Cross section of the joint bar of the Case Opt 10 39
Figure 59: von Mises stress contours of the joint bar model with cross section shown in Figure 58 39

List of Tables

Table 1: Elastic properties of joint bar material 5
Table 2: Mechanical property of the joint bar 5
Table 3: The von Mises stresses of the model shown in Case L 4 with different mesh sizes 18
Table 4: The effects of the pressure load on the maximum stress of the model its cross section shown in Figure 36 26
Table 5: Comparison of the volume and maximum von Mises stress of different modified joint bars 40

CENTRE

FOR RAILWAY ENGINEERING

Customer focused research and training

Central Queensland

UNIVERSITY