

TABLE OF CONTENTS

1. INTRODUCTION.....	9
2. CONCEPTUAL FRAMEWORK FOR HAZARD IDENTIFICATION IN THE RAILROAD STRUCTURE	15
2.1. Basic concepts.....	15
2.2. Division of hazards.....	19
2.3. Identification of hazards.....	23
2.4. Combination of hazards.....	28
2.5. Hazard awareness-building.....	29
2.6. Description of hazards.....	31
2.7. Major tasks leading to reduced hazards on railroads	34
3. RISK – CONCEPTS AND ASSESSMENT METHODS	37
3.1. Understanding risk	37
3.2. Risk calculation	40
3.3. Risk analysis.....	42
3.4. Examples of risks in railways.....	44
3.5. Risk in the railroad structure	47
3.6. Risks related to climate change	51
3.7. Computer programs for risk assessment on the railroad structure	54
4. CLASSIFICATION AND TYPOLOGY OF DEFECTS IN THE RAILROAD STRUCTURE.....	55
4.1. Standard classification and typology features.....	55
4.2. Division of railroad structure usability	57
4.3. Degradation of the railroad structure and the concept of its durability	58
4.4. General division of railroad damage.....	63
4.5. Possibilities to extend the general division of railroad damage	67
4.6. Experimental conformity assessment of defects and railroad structure damage.....	67
4.6.1. Typological groups and psychological scaling	67
4.6.2. Possibilities of using the division of damage to the railroad structure into typological groups in repair planning	78
4.6.3. Determination of damage dominance	79
5. DEVELOPMENT OF DEFECTS AND DAMAGE	83
5.1. Forms of defect and damage accumulation	83
5.2. Spread of defects and damage	83
5.3. Development of defects and damage and their reversibility	85

5.4.	Grading of hazards in terms of operational effects.....	94
5.5.	Model of evolutionary changes in surface conditions.....	99
5.6.	Inertia in decision-making and its consequences.....	103
6.	TOOLS, TECHNIQUES AND METHODS USED TO REDUCE HAZARDS	107
6.1.	General considerations	107
6.2.	Checklists	107
6.2.1.	Meaning of checklists.....	107
6.2.2.	Warning checklists	108
6.2.3.	Checklist example.....	110
6.3.	HAZOP analysis.....	116
6.4.	Root cause analysis	118
6.5.	Cause Map.....	130
6.6.	Tree Analyses.....	131
6.7.	Ishikawa diagram	134
6.8.	Pareto Analysis.....	135
6.9.	Forecasting	135
7.	RAILROAD STRUCTURE QUALITY AND HAZARDS	137
7.1.	General considerations	137
7.2.	The concept of railroad structure quality	137
7.3.	Modernisation programming and design deficiencies in relation to the railroad structure... 138	138
7.4.	Quality of railroad structure-related works.....	141
7.4.1.	General considerations.....	141
7.4.2.	Quality measures for railroad structure works	143
7.4.3.	Graduation of defects occurring in railroad structure-related works and their examples.....	148
7.4.4.	Comparison of the quality of railroad structure-related works in Poland and other countries	150
7.5.	Effectiveness of railroad structure-related works implemented as part of railway line modernisation	154
7.6.	Activities related to the quality of railroad structure works.....	160
7.6.1.	General considerations.....	160
7.6.2.	Works commissioning.....	160
7.6.3.	Preferences for contractors	162
7.6.4.	The importance of personal qualities in obtaining appropriate quality	163
7.6.5.	Impact of management on railroad structure quality	165
8.	CRACKS, FRACTURES AND DAMAGE TO THE RAILS	169
8.1.	Description of hazards.....	169
8.2.	Quantitative trends	171
8.3.	Rolling Contact Fatigue and other defects on the rolling surface of a rail.....	180
8.4.	Effects of Rolling Contact Fatigue	186
8.5.	Impact of dynamic interactions on rail cracking.....	188
8.6.	Importance of defect detection	193
8.7.	The importance of rail steel.....	195
8.8.	Possibilities of reducing rail cracks	197
8.8.1.	General considerations.....	197
8.8.2.	Possibilities of reducing head checks	198
8.8.2.1.	Structural and operational changes	198
8.8.2.2.	Increasing the rail profiling range.....	199
8.8.2.3.	Improving rail welding technology.....	201

9. TRACK BUCKLING	203
9.1. Hazard specificity	203
9.2. Criteria for determining CWR trackstability	206
9.3. Complementary factors	214
9.3.1. Type of key factors	214
9.3.2. Neutral temperature variations.....	214
9.3.3. Impact of rail vehicles	216
9.3.4. Railroad structure condition	221
9.4. Possibility to quantify the railroad structure condition in terms of track buckling hazards ..	224
9.5. Turnout buckling.....	226
9.6. Track buckling test	229
9.7. Track deformations wrongly classified as buckling	233
10. RAIL VEHICLE DERAILMENTS.....	237
10.1. Complexity of derailments	237
10.2. Diversity of derailment causes.....	237
10.3. Derailment specificity related to the railroad structure condition.....	239
10.4. Derailment research.....	243
10.5. Effects of derailments.....	252
10.6. Computer-aided research into derailment causes.....	254
10.7. Improving derailment cause identification	258
10.8. Research work undertaken after derailments and interpretation dilemmas.....	259
10.9. From the experience of an expert in derailment studies	260
10.10. Summary	263
AFTERWORD	265
REFERENCES.....	267

Safety engineering has developed rapidly in recent years and is divided into numerous specializations. Many higher education institutions have created majors such as Polish University of Technology (Wydział Inżynierski) (The Polish Academy of Sciences) (Wydział Inżynierski) and University of Technology (Wydział Inżynierski) (The Safety Engineering Curriculum Fund). Journals on this area are published and collected. Conferences are organized on safety in various areas (e.g., Safety Engineering is defined as a discipline that aims to develop theories and diagnostic methods and measures to protect people, the environment and working time. This is achieved by preventing that any potentially harmful and dangerous for safety. Certain specializations exist in this discipline, including technical safety engineering. Very different or long believed disciplines are also being created, such as activities in safety (2007).

The development of this research field raises the question of whether safety engineering should become part of civil engineering or a narrower, such as part of railroad. In reaching this question, one can consider what is more important procedure - developing new techniques which will enrich the already known or

* This is a study prepared by the UICR system, which creates the safe environment of high-speed trains which is the safe environment of the rail and rail* (Anglo-American* - 2007) (PRIMA) (2011)