



UCG

Univerzitet Crne Gore



UNIVERSITY OF MONTENEGRO
FACULTY OF CIVIL ENGINEERING

THE EIGHTH INTERNATIONAL CONFERENCE
CIVIL ENGINEERING - SCIENCE & PRACTICE

GNP 2022 PROCEEDINGS



Kolašin, March 2022



UNIVERSITY OF MONTENEGRO



FACULTY OF CIVIL ENGINEERING

**THE EIGHTH INTERNATIONAL CONFERENCE
CIVIL ENGINEERING - SCIENCE & PRACTICE**



GNP 2022 PROCEEDINGS

KOLAŠIN, 8-12 MARCH 2022

ISBN 978-86-82707-35-6

GNP 2022 PROCEEDINGS

- Publisher: **UNIVERSITY OF MONTENEGRO
FACULTY OF CIVIL ENGINEERING**
- For Publisher: **Prof. Marina Rakočević, Dr-Ing.**
- Editors-in-Chief: **Prof. Marina Rakočević, Dr-Ing.
Assoc. Prof. Biljana Šćepanović, Dr-Ing.**
- Editorial board: **Prof. Marina Rakočević, Dr-Ing.
Prof. Miloš Knežević, Dr-Ing.
Assoc. Prof. Biljana Šćepanović, Dr-Ing.
Assoc. Prof. Olga Mijušković, Dr-Ing.
Assist. Prof. Ivana Ćipranić, Dr-Ing.
Assist. Prof. Marija Jevrić, Dr-Ing.
Mladen Gogić, MSc, Dipl. Ing.
Boris Jevrić, Dipl. Ing.**
- Technical editing: **Boris Jevrić, Dipl. Ing.**
- Cover photo by: **Ilija Perić**
- Printing: **ARTGRAFIKA D.O.O.**
- Number of copies: **350**

CIP - Каталогизација у публикацији
Национална библиотека Црне Горе, Цетиње

ISBN 978-86-82707-35-6
COBISS.CG-ID 21036292

ISBN 978-86-82707-35-6



9 788682 707356 >



GNP 2022 SPONSORS

Co-Organiser of the Conference

ENGINEERS CHAMBER OF MONTENEGRO, CIVIL ENGINEERS CHAMBER
Podgorica, Montenegro

Gold Sponsor

CHINA ROAD AND BRIDGE CORPORATION, Podgorica, Montenegro

Silver Sponsor

SIKA SRBIJA, Šimanovci, Serbia

Bronze Sponsors

ARDEX Baustoff GmbH, Loosdorf, Austria

BBR ADRIA, Zagreb, Croatia

CEMEX MONTENEGRO, Podgorica, Montenegro

INSTITUT ZA GRAĐEVINARSTVO, Podgorica, Montenegro

INSTITUTE FOR THE DEVELOPMENT OF WATER RESOURCES
“JAROSLAV ČERNI”, Belgrade, Serbia

STRABAG, Podgorica, Montenegro

GNP 2022 SPONSORS

Friends of the Conference

ADING, Skopje, North Macedonia

CG RAD, Podgorica, Montenegro

DIASEN srl, Sassoferrato, Ancona, Italy

FONDACIJA PROFESOR ARSENIJE VUJOVIĆ, Podgorica, Montenegro

GeoGIS CONSULTANTS, Belgrade, Serbia

GEOPROJEKT, Podgorica, Montenegro

LOVČEN OSIGURANJE, Podgorica, Montenegro

MONTEPUT – PJ AUTOPUT BAR-BOLJARE, Podgorica, Montenegro

M SOLUTIONS, Podgorica, Montenegro

NATIONAL WATER ADMINISTRATION OF MONTENEGRO
Podgorica, Montenegro

NESHVYL, Belgrade, Serbia

PRODUKT BG INŽENJERING, Belgrade, Serbia

VIGORIS ECOTECH, Podgorica, Montenegro

Donors

AGENCY FOR ELECTRONIC COMMUNICATIONS AND POSTAL SERVICES
Podgorica, Montenegro

CAPITAL CITY PODGORICA, Montenegro

INSTITUTE FOR STANDARDIZATION OF MONTENEGRO
Podgorica, Montenegro

MINISTRY OF ECOLOGY, SPATIAL PLANNING AND URBANISM
Podgorica, Montenegro

MUNICIPALITY OF KOLAŠIN, Montenegro

NIKCOM, Nikšić, Montenegro

GNP 2022 Scientific Committee

INTERNATIONAL SCIENTIFIC BOARD

Professor Emeritus Charalampos Baniotopoulos

Aristotle University of Thessaloniki, Thessaloniki, Greece
University of Birmingham, Birmingham, United Kingdom

Prof. Dr Miroslav Bešević

University of Novi Sad, FCE Subotica, Subotica, Serbia

Prof. Dr Paulo Barreto Cachim

University of Aveiro, Aveiro, Portugal

Prof. Dr Cristina Câmpian

Technical University of Cluj-Napoca, Cluj-Napoca, Romania

Prof. Dr Corneliu Cismasiu

University NOVA, Lisbon, Portugal

Prof. Dr Ildi Cismasiu

University NOVA, Lisbon, Portugal

Prof. Dr Anca Constantin

Ovidius University of Constanta, Constanta, Romania

Assoc. Prof. Dr Saša Čvoro

University of Banja Luka, Banja Luka, Bosnia and Herzegovina

Prof. Dr Szymon Dawczyński

Silesian University of Technology, Gliwice, Poland

Prof. Dr Luisa María Gil Martín

University of Granada, Granada, Spain

Prof. Dr Marcin Górski

Silesian University of Technology, Gliwice, Poland

Prof. Dr Ay Lie Han

Diponegoro University, Semarang, Indonesia

Assoc. Prof. Dr Tomáš Hanák
Brno University of Technology, Brno, Czech Republic

Prof. Dr Wei Hao
Changsha University of Science and Technology, Changsha, China

Prof. Dr Enrique Hernández Montes
University of Granada, Granada, Spain

Dr Micha Horacek
BLT Wieselburg HBLFA Francisco Josephinum, Vienna, Austria

Prof. Dr Adnan Ibrahimović
University of Tuzla, Tuzla, Bosnia and Herzegovina

Assoc. Prof. Dr Nikša Jajac
University of Split, Split, Croatia

Prof. Dr Miloš Knežević
University of Montenegro, Podgorica, Montenegro

Assist. Prof. Dr Mitja Košir
University of Ljubljana, Ljubljana, Slovenia

Prof. Dr Janusz Witalis Kozubal
Wrocław University of Technology, Wrocław, Poland

Prof. Dr Vladan Kuzmanović
University of Belgrade, Belgrade, Serbia

Prof. Dr Stjepan Lakušić
University of Zagreb, Zagreb, Croatia

Prof. Dr Duško Lučić
University of Montenegro, Podgorica, Montenegro

Assoc. Prof. Dr Maria Mavrova-Guirguinova
University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria

Assoc. Prof. Dr Esad Mešić
University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Prof. Dr Nicola Nistico
Sapienza University of Rome, Rome, Italy

Prof. Dr Hartmut Pasternak
Brandenburg University of Technology, Cottbus – Senftenberg, Germany

Prof. Dr Maja Prskalo
University of Mostar, Mostar, Bosnia and Herzegovina

Prof. Dr Vlastimir Radonjanin
University of Novi Sad, FTS, Novi Sad, Serbia

Prof. Dr Marina Rakočević
University of Montenegro, Podgorica, Montenegro

Assoc. Prof. Dr Aleksandar Ristovski
Faculty of Technical Sciences, Kosovska Mitrovica

Prof. Dr Maria Fernanda da Silva Rodrigues
University of Aveiro, Aveiro, Portugal

Assoc. Prof. Dr Mili Selimotić
University Džemal Bijedić, Mostar, Bosnia and Herzegovina

Prof. Dr Božo Soldo
University North, Varaždin, Croatia

Prof. Dr Zlatko Srbinoski
Ss. Cyril and Methodius University, FCE, Skopje, North Macedonia

Assoc. Prof. Dr Milena Stavrić
Graz University of Technology, Graz, Austria

Assoc. Prof. Dr Biljana Šćepanović
University of Montenegro, Podgorica, Montenegro

Assoc. Prof. Dr Vlatko Šešov
Ss. Cyril and Methodius University, IZIIS, Skopje, North Macedonia

Prof. Dr Andrej Šoltész
Slovak University of Technology, Bratislava, Slovak Republic

Prof. Dr Ivana Štimac Grandić
University of Rijeka, Rijeka, Croatia

Prof. Dr Slaviša Trajković
University of Niš, Niš, Serbia

Assoc. Prof. Dr Damir Varevac
Josip Juraj Strossmayer University, Osijek, Croatia

Prof. Dr Milan Veljković
Delft University of Technology, Delft, The Netherlands

Prof. Dr Guoxin Wang

Dalian University of Technology, Dalian, China

Prof. Dr Vesna Žegarac Leskovar

University of Maribor, Maribor, Slovenia

REVIEW BOARD

Assoc. Prof. Dr Srđa Aleksić

University of Montenegro, Podgorica, Montenegro

Prof. Dr Ivana Banjad Pečur

University of Zagreb, Zagreb, Croatia

Prof. Dr Meri Cvetkovska

Ss. Cyril and Methodius University, FCE, Skopje, North Macedonia

Assist. Prof. Dr Ivana Čipranić

University of Montenegro, Podgorica, Montenegro

Prof. Dr Velimir Dutina

Faculty of Technical Sciences, Kosovska Mitrovica

Prof. Dr Nebojša Đuranović

University of Montenegro, Podgorica, Montenegro

Assist. Prof. Dr Radovan Đurović

University of Montenegro, Podgorica, Montenegro

Prof. Dr Nađa Folić

University of Novi Sad, FTS, Novi Sad, Serbia

Professor Emeritus Radomir Folić

University of Novi Sad, FTS, Novi Sad, Serbia

Prof. Dr Emina Hadžić

University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Prof. Dr Nenad Ivanišević

University of Belgrade, Belgrade, Serbia

Assist. Prof. Dr Biljana Ivanović
University of Montenegro, Podgorica, Montenegro

Prof. Dr Srđan Janković
University of Montenegro, Podgorica, Montenegro

Assist. Prof. Dr Marija Jevrić
University of Montenegro, Podgorica, Montenegro

Assist. Prof. Dr Tatjana Kočetov Mišulić
University of Novi Sad, FTS, Novi Sad, Serbia

Prof. Dr Đorđe Lađinović
University of Novi Sad, FTS, Novi Sad, Serbia

Prof. Dr Mirjana Malešev
University of Novi Sad, FTS, Novi Sad, Serbia

Assoc. Prof. Dr Ljubo Marković
Faculty of Technical Sciences, Kosovska Mitrovica

Prof. Dr Zlatko Marković
University of Belgrade, Belgrade, Serbia

Assist. Prof. Dr Jelena Pejović
University of Montenegro, Podgorica, Montenegro

Prof. Dr Radenko Pejović
University of Montenegro, Podgorica, Montenegro

Prof. Dr Miroslav Premrov
University of Maribor, Maribor, Slovenia

Assoc. Prof. Dr Milan Radulović
University of Montenegro, Podgorica, Montenegro

Assist. Prof. Dr Milivoje Rogač
University of Montenegro, Podgorica, Montenegro

Assist. Prof. Dr Snežana Rutešić
University of Montenegro, Podgorica, Montenegro

Prof. Dr Todorka Samardžioska
Ss. Cyril and Methodius University, FCE, Skopje, North Macedonia

Prof. Dr Goran Sekulić

University of Montenegro, Podgorica, Montenegro

Assoc. Prof. Dr Radmila Sindić Grebović

University of Montenegro, Podgorica, Montenegro

Prof. Dr Boško Stevanović

University of Belgrade, Belgrade, Serbia

Assoc. Prof. Dr Merima Šahinagić-Isović

University Džemal Bijedić, Mostar, Bosnia and Herzegovina

Prof. Dr Zvonko Tomanović

University of Montenegro, Podgorica, Montenegro

Prof. Dr Milan Trivunić

University of Novi Sad, FTS, Novi Sad, Serbia

Prof. Dr Mladen Ulićević

University of Montenegro, Podgorica, Montenegro

Prof. Dr Dušan Vuksanović

University of Montenegro, Podgorica, Montenegro

Assoc. Prof. Dr Zlatko Zafirovski

Ss. Cyril and Methodius University, FCE, Skopje, North Macedonia

Prof. Dr Radomir Zejak

University of Montenegro, Podgorica, Montenegro

Assist. Prof. Dr Slobodan Živaljević

University of Montenegro, Podgorica, Montenegro

Assoc. Prof. Dr Ljiljana Žugić

University of Montenegro, Podgorica, Montenegro

GNP 2022 Organising Committee

*University of Montenegro
Faculty of Civil Engineering*

*NGO “Građevinarstvo – nauka i praksa – GNP”
Podgorica, Montenegro*

Prof. Marina Rakočević, Dr.-Ing.

Prof. Miloš Knežević, Dr.-Ing.

Assoc. Prof. Biljana Šćepanović, Dr.-Ing.

Assoc. Prof. Olga Mijušković, Dr.-Ing.

Assist. Prof. Ivana Čipranić, Dr.-Ing.

Assist. Prof. Marija Jevrić, Dr.-Ing.

Mladen Gogić, MSc

Mladen Muhadinović, MSc

Miodrag Bujišić, MSc

Petar Subotić, MSc

Ivana Drobnjak, MSc

Nina Nikolić, MSc

Milena Ostojić, MSc

THE FOREWORD

Traditionally, for the eighth time now, the International Conference “Civil Engineering – Science and Practice”, GNP 2022 gathers us aiming at considering various topics and exchanging ideas of contemporary trends in civil engineering, once again in beautiful Kolašin.

The previous conference GNP 2020 had to be finished one day earlier than planned, due to the outbreak of COVID-19 pandemic. It has been followed by two-year period of slow investment activities, not only in the domain of civil engineering, and rapid ICT development. One of the aims of GNP 2022 is to contribute to the change of the current economic situation and, consequently, to the evolution of construction sector, through innovation, research, discussions and exchange of views.

GNP 2022 Proceedings collects 126 papers of 290 authors. Much higher number of conference participants, from 26 countries of Europe and beyond, give their precious contribution to GNP 2022, not only through writing, but also through other forms of active participation, such as paper reviewing and presentation, personal presence or online lecturing, significant support of sponsors and friends from Montenegro and abroad. We are grateful to all these colleagues and companies/institutions for enabling this GNP conference to be as it is.

Special thanks for all support and assistance in GNP 2022 realisation to the co-organiser – Engineers Chamber of Montenegro, Chamber of Civil Engineers.

We do hope discussions and presentations from GNP 2022 will be an additional incentive to advance the future of construction, in function of peace and progress of humanity.

Podgorica, March 2022

GNP 2022 ORGANISING COMMITTEE



**8TH INTERNATIONAL CONFERENCE
CIVIL ENGINEERING - SCIENCE AND PRACTICE**

KOLAŠIN, 8-12 MARCH 2022

TABLE OF CONTENTS

INVITED LECTURES 1

Paulo Cachim

**SMART CARBON-CONCRETE SENSORS
FOR TRANSPORT INFRASTRUCTURES 3**

Jelena Dobrić

**STABILITY CRITERIA FOR STAINLESS STEEL
EQUAL-LEG ANGLE COLUMNS 15**

Luisa María Gil-Martín, Luisa María Hdz-Gil, Stefano Miccoli, Enrique Hernández-Montes

**ORIGIN OF THE CATENARY, THE TRUE FORM
OF THE ARCH: TAQ-I KISRA 39**

Hartmut Pasternak

EXTRAORDINARY STEEL STRUCTURES IN GERMANY 45

Svetislav Popović, Christian Stelzl

STATE OF THE ART IN THE DESIGN OF STEEL ROLLER-COASTERS 55

Ivana Štimac Grandić

**VIBRATION SERVICEABILITY OF FOOTBRIDGES: CURRENT STATE
AND COMMENTARY ON CODES, NORMS AND GUIDELINES 71**

**THEORETICAL AND EXPERIMENTAL RESEARCH
IN CIVIL ENGINEERING 93**

Senka Bajić, Vladimir Vukobratović

**EARTHQUAKE-INDUCED SNOW AVALANCHES:
THE CRITICAL HEIGHT OF A SNOW LAYER 95**

Vasilije Bojović, Marina Rakočević

**FREE VIBRATION ANALYSIS OF SYMMETRIC
CROSS-PLY LAMINATED COMPOSITE PLATES 101**

<i>Meri Cvetkovska, Koce Todorov, Maosen Cao, Vladimir Vitanov, Cvetanka Chifliganec, Milica Jovanoska, Riste Volcev, Nikola Postolov</i>	
NUMERICAL ANALYSIS ON FIRE RESISTANCE OF RC FRAME STRUCTURES DAMAGED BY SEISMIC ACTION	111
<i>Aleksandar Čeranić, Milica Bendić, Saša Kovačević, Nenad Marković</i>	
INFLUENCE OF LONGITUDINAL STIFFENERS ON BEHAVIOR AND ULTIMATE RESISTANCE OF PLATE GIRDERS SUBJECTED TO PATCH LOADING	119
<i>Marina Četković</i>	
LAYERWISE FINITE ELEMENT FOR FREE VIBRATION OF GEOMETRICALLY IMPERFECT COMPOSITE PLATES	127
<i>Ivana Drobnjak, Jelena Pejović</i>	
SEISMIC ASSESSMENT OF AN EXISTING REINFORCED CONCRETE BUILDING	135
<i>Ivan Duvnjak, Suzana Ereiz, Domagoj Damjanović, Marko Bartolac, Janko Koščak, Jurica Pajan</i>	
CHALLENGES IN MODEL UPDATING OF CULTURAL HERITAGE STRUCTURES	143
<i>Filip Đorđević, Svetlana M. Kostić</i>	
PREDICTION OF ULTIMATE COMPRESSIVE STRENGTH OF CCFT COLUMNS USING MACHINE LEARNING ALGORITHMS	151
<i>Mirjana Đukić, Zlatko Marković, Duško Lučić</i>	
PRE-EXPERIMENTAL ANALYSIS OF ASYMMETRIC COMPOSITE SLIM FLOOR BEAM WITH WEB OPENINGS	159
<i>Eduard Fot, Dalibor Gelo, Šime Serdarević, Daniel Martinović</i>	
DYNAMIC ANALYSIS OF A MULTI-STOREY STRUCTURE USING MULTIPLE DYNAMIC METHODS	167
<i>Milena Janković, Duško Lučić</i>	
CODE FOR THE DESIGN AND OPTIMIZATION OF K GAP JOINTS COMPOSED OF CIRCULAR HOLLOW SECTIONS	175
<i>Đorđe Jovanović, Tanja Nožica</i>	
NUMERICAL ANALYSIS OF STEEL STAIRS VIBRATIONS	183
<i>Marino Jurišić, Alen Harapin</i>	
EXPERIMENTAL STRAIN MEASUREMENTS OF A PRESTRESSED BALANCED CANTILEVER BRIDGE	191
<i>Šemso Kalač, Naja Zejnelagić, Đorđe Đuričić, Duško Lučić</i>	
PROPOSAL OF ANALYTICAL EXPRESSION FOR DETERMINATION OF LOAD CAPACITY FOR ALUMINIUM SQUARE HOLLOW SECTION (SHS) K JOINTS UNDER CHORD TENSION	199
<i>Kopitović-Vuković, Radomir Zejak, Marija Jevrić, Nikola Baša</i>	
DEFLECTION CALCULATION OF RC T-BEAMS EXTERNALLY STRENGTHENED WITH CARBON MATERIAL	207

<i>Stojan Kravanja, Tomaž Žula, Primož Jelušič</i> OPTIMIZATION OF STEEL AND TIMBER HALLS	217
<i>Dejan Matic, Jelena Dobrić, Milan Spremić</i> PREDICTED ULTIMATE RESISTANCES OF COMPRESSED COLD-FORMED CHANNEL SECTIONS ACCORDING TO EFFECTIVE WIDTH METHOD AND DIRECT STRENGTH METHOD	225
<i>Aleksandar Milajić, Dejan Beljaković, Zorica Milovanović Jeknić, Lejla Vujičić, Irena Parović</i> COMPARATIVE ANALYSIS OF HYBRID MULTI-OBJECTIVE ALGORITHMS FOR STRUCTURAL OPTIMIZATION	233
<i>Milica Mirković Marjanović, Snežana Ilić, Aleksandar Kijanović, Goran Todorović, Radovan Gospavić</i> EXPERIMENTAL ANALYSIS OF FIRE RESISTANCE OF CLAY HOLLOW-BRICK MASONRY NON-LOAD BEARING WALL	241
<i>Zoran Mišković, Marina Latinović Krndija, Marko Popović, Siniša Savatović</i> MODAL ANALYSIS OF THE SUSPENSION FOOTBRIDGE OVER RIVER VRBAS IN BANJA LUKA	249
<i>Zoran Mišković, Vesna Lazarević, Milorad Ivetić, Miloš Hranisavljević, Ljiljana Mišković</i> STRAIN MEASUREMENTS DURING STATIC PILE TESTING: A CASE STUDY OF TWO PILES WITH DIFERENT DIAMETER AND LENGTH	257
<i>Ivan Nackov, Jelena Dobrić</i> STRUCTURAL PERFORMANCE OF HIGH STRENGTH STEEL I AND H SECTIONS	265
<i>Nina Nikolić, Biljana Šćepanović</i> ANALYSIS OF PRESSED BRACE AND K-JOINT OF WELDED ALUMINIUM LATTICE STRUCTURE MADE OF CHS PROFILES	273
<i>Bojan Raspopović, Slobodan Živaljević</i> EXPERIMENTAL TESTING OF THE ENERGY ABSORPTION CAPACITY OF SHOTCRETE	281
<i>Milivoje Rogač, Srđa Aleksić, Duško Lučić</i> TESTING OF THIN-WALLED I-GIRDER SUBJECTED TO PATCH LOADING ...	289
<i>Radmila Sindić Grebović</i> MODELLING OF HIGH-STRENGTH CONCRETE IN THE SHEAR TRANSFER ZONE	297
<i>Anka Starčev-Čurčin, Andrija Rašeta, Miloš Šešlija, Igor Džolev, Dragan Manojlović</i> EXPERIMENTAL TESTING AND NUMERICAL ANALYSIS OF REINFORCED CONCRETE WALL MEMBERS	305
<i>Petar Subotić, Biljana Šćepanović</i> IMPROVED M_{cr}-L CURVES FOR HOT ROLLED IPE SECTIONS	315
<i>Andrej Štrukelj</i> MEASUREMENTS OF VEHICLE RESPONSE TO WIND GUSTS DURING TESTING THE EFFECTIVENESS OF WINDBREAKS	323

<i>Vladimir Živaljević, Milan Blagojević, Đorđe Jovanović, Dušan Kovačević</i> GEOMETRY CONTROL OF THE COLD-FORMED STEEL MEMBERS USING THE OPTICAL 3D MEASURING SYSTEM	333
<i>Tomaž Žula, Stojan Kravanja, Primož Jelušič</i> SUSTAINABILITY PROFIT GENERATED BY THE OPTIMIZATION OF SIMPLY SUPPORTED BEAMS	341

DESIGN AND BUILDING OF STRUCTURES 347

<i>Goran Milutinović</i> TIED ARCH BRIDGE AT 2ND AVENUE OVER I-94, DETROIT, U.S.A.: EXPERIENCES DURING VALUE ENGINEERING PROPOSAL AND CONSTRUCTION ENGINEERING	349
<i>Radenko Pejović, Nikola Luković, Bojan Đonović, Jelena Pejović, Mladen Muhadinović</i> STRUCTURAL AND ARCHITECTURAL DESIGN OF SMOKOVAC TOLL COLLECTION RAMP ON THE SECTION OF THE SMOKOVAC-MATEŠEVO HIGHWAY	357
<i>Radenko Pejović, Nikola Luković, Jelena Pejović, Bojan Đonović, Nina Serdar, Mladen Muhadinović</i> STRUCTURAL AND ARCHITECTURAL DESIGN OF MAINTENANCE BASE ON PELEV BRIJEG FOR SECTION OF THE SMOKOVAC-MATEŠEVO HIGHWAY	365
<i>Milan Spremić, Nemanja Dinčić, Isidora Jakovljević, Nina Gluhović, Jelena Dobrić</i> FIRE LOAD FOR PERFORMANCE FIRE DESIGN OF CAR PARK STEEL STRUCTURE	373

ASEISMIC PLANNING, DESIGN AND BUILDING 381

<i>Dejan Dragojević, Željko Žugčić, Dušan Berisavljević</i> SITE SPECIFIC GROUND MOTION EARTHQUAKE RESPONSE STUDY – CASE STUDY AT THE SITE OF CANADIAN EMBASSY RESIDENCE IN BELGRADE	383
<i>Daniel Martinović, Šime Serdarević, Dalibor Gelo, Eduard Fot,</i> CALCULATION OF SEISMIC RESISTANCE OF AN EXISTING BUILDING	393
<i>Ivan Mrdak</i> NONLINEAR STATIC ANALYSIS OF FRAME STRUCTURE DESIGNED IN ACCORDANCE WITH EUROCODE 8	401
<i>Aleksandra Radujković, Đorđe Lađinović</i> SEISMIC RESPONSE OF RC FRAMES FOR TWO LIMIT STATES ACCORDING TO EN 1998-3	409

Nina Serdar, Jelena Pejović

CHALLENGES IN DEVELOPING NATIONAL SEISMIC RISK ASSESSMENT 415

Vladimir Vukobratović, Dragan Manojlović, Ivan Lukić

SEISMIC RESPONSE OF AN EXISTING MASONRY MONASTERY TOWER 423

SPECIAL ISSUES OF DESIGN AND CONSTRUCTION 431

Nikola Čadenović

CONSTRUCTION METHOD FOR TUNNEL UNDER THE BAY OF KOTOR 433

Radomir Folić, Nenad Stojković, Zoran Brujić

**SERVICE LIFE AND DURABILITY OF CONCRETE
STRUCTURE - SUSTAINABLE CONSTRUCTION 445**

Dorđe Jovanović, Drago Žarković, Ivan Pijanić

**NON-LINEAR ANALYSIS AS TOOL FOR DAMAGE EXPLANATION
OF SILO GALERY STRUCTURE 455**

Cveta Lazić, Suzana Draganić, Olivera Bukvić, Mirjana Laban, Meri Cvetkovska

FIRE RISK ASSESSMENT IN RESIDENTIAL UNITS 463

Miroslav Premrov, Vesna Žegarac Leskovar

**STUDY ON MULTI-FUNCTIONAL ANALYSIS
OF HIGH-RISE TIMBER BUILDINGS 471**

Bratislav Stipanić

ERECTION EXAMPLES OF STEEL BRIDGES OVER SAVA RIVER 481

BUILDING MATERIALS 491

Katarina Didulica, Ana Baričević, Ivana Banjad Pečur

**A REVIEW OF EARLY AGE SHRINKAGE DEFORMATIONS
IN CEMENTITIOUS COMPOSITES 493**

Ivan Gabrijel, Ivana Banjad Pečur

**ASSESSMENT OF CONCRETE COMPRESSIVE STRENGTH IN
STRUCTURES - COMPARISON OF PAST AND CURRENT PRACTICES 501**

Ksenija Janković, Marko Stojanović, Dragan Bojović, Anja Terzić, Srboľjub Stanković

**INFLUENCE OF WATER/CEMENT RATIO ON THE PROPERTIES
OF FRESH SCC WITH FLY ASH ADDITION 509**

Tatjana Kočetov Mišulić, Aleksandra Radujković

**DIFFERENCIES IN STATISTICAL EVALUATION
OF TIMBER BENDING STRENGTH ACCORDING EN 8 AND EN 8 517**

<i>Slobodan Šupić, Vesna Bulatović, Mirjana Malešev, Vlastimir Radonjanin, Vladan Pantić</i> FROM WASTE TO RESOURCE - PART 1: CHARACTERIZATION OF FLY ASH, SLAG AND WHEAT STRAW ASH	525
<i>Slobodan Šupić, Vesna Bulatović, Mirjana Malešev, Vlastimir Radonjanin, Vladan Pantić</i> FROM WASTE TO RESOURCE - PART 2: MASONRY MORTAR INCORPORATING FLY ASH, SLAG AND WHEAT STRAW ASH	533
<i>Radimir Zejak, Senka Zečević, Katarina Mirković</i> THE POSSIBILITY OF USING FLY ASH FROM THE LANDFILL MALJEVAC AND THE TPP PLJEVLJA IN CONCRETE PRODUCTION	543

MAINTENANCE AND REPAIR OF STRUCTURES

MONITORING OF STRUCTURES DURING CONSTRUCTION AND EXPLOITATION 551

<i>Miroslav Bešević, Neđo Đurić, Martina Vojnić Purčar, Ljiljana Kozarić, Smilja Bursac</i> LOAD BEARING STRUCTURE OF THE EXCHANGE STATION OF BLOCK A TENT A - OBRENOVAC	553
--	------------

<i>Miloš Knežević, Ivana Tešović, Radenko Pejović, Duško Lučić, Kemal Abdić, Miloš Vučinić, Teodora Bulatović, Kostantin Dragović, Jelena Perović, Ivan Popović, Anđela Jašović</i> COMPLEXITY OF REHABILITATION WORKS ON THE CONCRETE BRIDGES ON THE RAILWAY LINE "VRBNICA-BAR"	565
---	------------

<i>Liljana B. Mijalkova, Elena Delova, Živko Božinovski</i> ANALITICAL APROACH FOR STRENGTHENING OF HISTORIC BUILDING "ARMY CLUB" IN BITOLA DAMAGED IN THE 1994 EARTHQUAKE	573
--	------------

<i>Dragan Žarković, Stefanela Žarković</i> QUALITY OF ALL PHASES OF THE LIFE CYCLE OF ENGINEERING FACILITIES - SAFETY CONDITION AND BEST PROTECTION AGAINST DAMAGE. CASE EXAMPLE: ANTENNA PILLAR DEMOLITION	581
---	------------

BUILDING REGULATIONS AND CODES 589

<i>Milica Mirković Marjanović, Snežana Ilić, Aleksandar Kijanović, Goran Todorović, Radovan Gospavić</i> OVERVIEW OF THE NEW RULEBOOK ON TESTING FIRE RESISTANCE, EXTERNAL FIRE PERFORMANCES AND REACTION TO FIRE IN THE REPUBLIC OF SERBIA	591
---	------------

<i>Mladen Muhadinović, Petar Subotić, Duško Lučić</i> OVERVIEW OF NATIONALLY DETERMINED PARAMETERS IN EN 1993-1-8 ..	599
--	------------

Petar Subotić, Mladen Muhadinović, Duško Lučić

OVERVIEW OF NATIONALLY DETERMINED PARAMETERS IN EN 1993-1-1 .. 607

PLANNING, DESIGN AND CONSTRUCTION OF ROADS AND RAILWAYS 617

Laura Brigita Parežnik, Marko Renčelj

**COMPARISON OF DESIGN ELEMENTS REGARDING GRADE-SEPARATED
INTERCHANGES AND JUNCTIONS BETWEEN DIFFERENT COUNTRIES 619**

Riste Ristov, Ivona Nedevska, Zlatko Zafirovski, Vasko Gacevski, Marijana Lazarevska

**PROCESS OF DESIGNING AN ACCESS ROAD
AND A WINDMILL PLATEAU IN BOGDANCI 627**

Riste Ristov, Ivona Nedevska, Zlatko Zafirovski, Slobodan Ognjenovic, Vasko Gacevski

MEASURES TO IMPROVE SAFETY ON EXISTING MAIN STREET 101 635

SPATIAL, ARCHITECTURAL AND URBAN PLANNING AND DESIGN HERITAGE PROTECTION 645

Nada Kurtović Folić, Radomir Folić

A CONTRIBUTION TO PREDICTING THE FUTURE OF CULTURAL HERITAGE .. 647

Ljubo Marković, Julija Aleksić, Rada Radulović, Mirjana Miletić

**ECONOMIC BENEFITS FROM IMPROVING HOUSING
CONTAINER CLADDING IN THE REPUBLIC OF SERBIA 657**

Nevena Mašanović, Marija Jevrić

**MONTENEGRIN RURAL SETTLEMENTS – PATTERNS, ATTRIBUTES
AND ISSUES, ACCORDING TO THE REGIONAL AFFILIATION 665**

Marija Mihajlović, Marko Mihajlović, Ljiljana Stošić Mihajlović

**CONCEPT OF BIOCLIMATIC DESIGN AND PLANNING
IN ARCHITECTURE AND BUILDINGS 673**

Jaka Potočnik, Mitja Košir

**PREDICTING THE MELANOPIC POTENTIAL OF INDOOR
COLOURED SURFACES USING ARTIFICIAL NEURAL NETWORKS 681**

ENVIRONMENTAL PROTECTION 689

Marko Čeček, Ivana Čipranic, Merima Šahinagić-Isović, Radmila Marković, Zoran Stevanović
THE POSSIBILITIES OF USING RED MUD IN BUILDING MATERIALS 691

Gregor Kravanja, Andrej Ivanič, Samo Lubej
TOWARDS GREEN CEMENT PRODUCTION 699

Ivona Krulanović, Ivana Čipranić, Marija Jevrić, Milena Ostojčić
**POSSIBILITIES OF PREDICTIONS OF MUNICIPAL SOLID WASTE
AMOUNT IN MONTENEGRO USING NEURAL NETWORKS 705**

**ENERGY EFFICIENCY, ENERGY-EFFICIENT
DESIGN AND BUILDING 713**

David Božiček, Mateja Dovjak
**IMPACT OF THERMAL INERTIA AND ROOM ORIENTATION ON
ENERGY DEMAND AND THERMAL COMFORT IN AN OFFICE BUILDING 715**

Ivana Burić, Marija Nišavić
**PRINCIPLES OF ENERGY EFFICIENCY IN THE PROCESS
OF DESIGNING RESIDENTIAL SETTLEMENT SADINE 723**

Liljana Dimevska, Meri Cvetkovska, Ana Trombeva Gavriloska, Mirjana Laban
**BUILDING ENERGY SIMULATION ANALYSYS BASED ON IN-SITU
MEASUREMENTS BEFORE AND AFTER INSULATION APPLICATION 731**

Dragan Kostić, Veliborka Bogdanović, Miomir Vasov, Vuk Milošević, Marko Ilić
**METHODOLOGICAL APPROACH TO MANAGEMENT
OF AMBIENT PARAMETERS IN ORDER TO PREVENT
CONDENSATION ON STRUCTURAL TEXTILE MEMBRANES 739**

Veronica Martins Gnecco, Luka Pajek
**ANALYSIS OF FIXED SHADING DEVICES
IN BRAZILIAN ELEMENTARY SCHOOLS
REGARDING COOLING ENERGY DEMAND AND DAYLIGHTING 747**

Marija Mihajlović, Marko Mihajlović, Ljiljana Stošić Mihajlović
**SIGNIFICANCE AND ROLE OF ARCHITECTURE
IN ENERGY EFFICIENT BUILDINGS 755**

Luka Pajek, Mitja Košir
**IMPLICATIONS OF PROJECTED RCP4.5 AND RCP8.5 CLIMATE CHANGE
SCENARIOS FOR THE BIOCLIMATIC POTENTIAL OF PODGORICA 763**

Maja Prskalo, Tatjana Džeba, Amira Galić
**SUSTAINABILITY OF WATER SUPPLY SYSTEMS USING
INTERNAL AND EXTERNAL RENEWABLE ENERGY SOURCES 771**

HYDROTECHNICS 779

Ivana Čipranić, Marija Jevrić, Milena Ostojić, Goran Sekulić, Snežana Rutešić
BURST FREQUENCY IN WATER DISTRIBUTION SYSTEM 781

Matej Čehovin, Andreja Žgajnar Gotvajn
**HYBRID HYDRODYNAMIC CAVITATION AND ADVANCED OXIDATION
 FOR REMOVAL OF NATURAL ORGANIC MATTER FROM
 DRINKING WATER – SELECTED ASPECTS 789**

Goran Jeftenić, Ljubomir Budinski, Slobodan Kolaković, Danilo Stipić, Marijana Milić
**MATHEMATICAL MODELLING OF GROUNDWATER
 LEVEL LOWERING USING GMS 797**

Milena Ostojić, Ivana Čipranić, Goran Sekulić
**CURRENT STATE OF NATIONAL FLOOD RISK ASSESSMENT
 IN MONTENEGRO 807**

Siniša Višnjić, Krsto Minić, Saveta Đuričić
THE SEWAGE SYSTEM IN PLJEVLJA - OPERATION CHALLENGES 815

Siniša Višnjić, Krsto Minić, Saveta Đuričić
**ANALYSIS OF POSSIBILITIES OF MICRO HYDROPOWER PLANT
 BUIL-UP ON THE DAPSIĆE WATER SUPPLY SYSTEM 823**

**GEOLOGY, HYDROGEOLOGY AND GEOTECHNICS
 IN CIVIL ENGINEERING 831**

Neđo Đurić, Miroslav Bešević, Smilja Bursać, Dijana Đurić
**CHARACTERISTICS OF LAPORY ROCKS AT THE SILOS LOCATION
 WITHIN THE “MOLARIS” MILL COMPLEX, IN KOZLUK
 NEAR ZVORNIK IN THE REPUBLIC OF SRPSKA 833**

Primož Jelušič, Stojan Kravanja, Tomaž Žula
**NUMERICAL MODELLING AND DESIGN
 OF GEOSYNTHETIC REINFORCED SOIL BRIDGE ABUTMENT 841**

Borut Macuh, Sašo Kos
**RETAINING STRUCTURE PK-18 AS A PART OF RECONSTRUCTION
 OF THE G2-108 HRASTNIK - ZIDANI MOST ROAD 849**

Snežana Maraš-Dragojević
**EUROCODE 7 AND DESIGN OF DEEP EXCAVATIONS
 AND TUNNELS USING FINITE ELEMENT METHOD 857**

Borko Miladinović, Slobodan Živaljević, Zvonko Tomanović
ESTIMATION OF THE STATIC VERTICAL SUBGRADE REACTION MODULUS .. 865

Borko Miladinović, Slobodan Živaljević, Zvonko Tomanović
LATERALLY LOADED PILES IN WINKLER'S ELASTIC MEDIA 873

Maja Prskalo, Ana Majstorović

**ANALYSIS AND METHODS OF APPLICATION
OF DIFFERENT EMBEDDED WALLS IN URBAN ENVIRONMENTS 881**

SURVEYING/GEODESY IN CIVIL ENGINEERING 889

Tatjana Budimirov, Vladimir Bulatović, Marko Marković, Mehmed Batilović, Zoran Sušić

PRECISE POINT POSITIONING – PPP METHOD 891

Tanja Đukanović, Sanja Tucikešić, Radovan Đurović

**COMPARATIVE ANALYSIS COORDINATE USING METHODS
OF GPS-RTK AND TOTAL STATION THE OF AN AREA LANDSLIDES 899**

Sanja Grekulović, Nikola Paunković, Dušan Petković,

Miljana Todorović Drakul, Slavica Ilijević

**FIELD PROCEDURE FOR ESTIMATION OF ANTENNA
PHASE CENTER VARIATION WITH EXPANDED
MEASUREMENT UNCERTAINTY CALCULATION 907**

Jovana Maksimović, Mehmed Batilović, Zoran Sušić, Radovan Đurović, Marko Marković,

Vladimir Bulatović, Gojko Nikolić

**PROJECT OF MICRO-NETWORK AND GEODETIC
SETTING-OUT OF THE PRESLO BRIDGE 915**

Branko Milovanović, Slavko Vasiljević, Radovan Đurović, Jovan Popović, Petko Vranić

WIND TURBINE COLUMN GEOMETRY CONTROL 923

Bilbil Nurçe, Eduart Blloshmi, Bledar Sina

CADASTRAL MAPPING IN ALBANIA 931

Bilbil Nurçe, Bledar Sina, Eduart Blloshmi

**TRANSFORMATION OF ELLIPSOIDAL HEIGHTS INTO ORTHOMETRIC
THROUGH A LINEAR INTERPOLATION POLYNOMIAL 939**

Gligorije Perović

**OPTIMIZATION OF GPS MEASUREMENT ACCURACY
IN GEODETIC CONTROL NETWORKS 947**

Vladimir Petrović, Bogdan Bojović, Tatjana Đurić, Mirko Borisov, Zoran Ilić, Nenad Rakičević

**GIS / 3D SOLUTIONS IN THE FUNCTION
OF MANAGEMENT IMPROVEMENT IN AGRICULTURE 959**

Hakile Resulbegović, Biljana Stamatović

**SPATIAL STATISTICS AND APPLICATION
OF THE GLOBAL POSITIONING SYSTEM IN FIELD SURVEYS 969**

Milan Trifković, Miroslav Kuburić, Žarko Nestorović

**THE INFLUENCE OF CHANGING POINTS' POSITION
DURING MEASUREMENTS ON ADJUSTED COORDINATES
IN SPECIAL GEODETIC NETWORKS 975**

MANAGEMENT IN CIVIL ENGINEERING 983*Željka Beljkaš, Mladen Gogić, Nina Serdar***AN OVERVIEW OF THE STUDY ON TECHNICAL-TECHNOLOGICAL AND ORGANIZATIONAL ELEMENTS FOR THE CONSTRUCTION OF A BRIDGE ŠAMIČKI POTOK ON BUDVA BYPASS 985***Željka Beljkaš, Mioš Knežević, Marko Knežević, Nadežda Lučić***CONSTRUCTION OF THE CONCRETE STRUCTURES –
– LEGAL AND TECHNICAL REQUIREMENTS 995***Zdravko Maksimović, Mirjana Laban, Sandra Nedeljković***FROM REACTION TO PREVENTION – SYSTEM OF CIVIL PROTECTION
IN THE CITY OF KRALJEVO 1005***Srđan Topalović, Lana Vukmirović-Mišić***DIFFERENCE BETWEEN ROLES OF THE ENGINEER AS PER FIDIC CONDITIONS
OF CONTRACTS AND ENGINEERING SUPERVISION IN ACCORDANCE WITH
LAW ON SPATIAL PLANNING AND CONSTRUCTION OF MONTENEGRO 1013***Dragan Žarković, Stefanela Žarković***RESEARCH OF THE IMPORTANCE OF LEGAL AND ECONOMIC ENVIRONMENT
ON THE QUALITY OF CORPORATE GOVERNANCE, IN THE REALIZATION
OF INVESTMENT ENTERPRISES IN CONSTRUCTION 1023****INFORMATICS AND MULTIMEDIA TECHNOLOGY IN CIVIL
ENGINEERING 1031***Dorđe Donović, Jelena Pejović, Nina Serdar***TOWARDS MONTENEGRO SEISMIC RISK ASSESSMENT
INFORMATION SYSTEM 1033***Sofija Kekez***CHALLENGES OF PREDICTING ELECTRICAL BEHAVIOR
OF SELF-SENSING CONCRETE 1041***Ljubo Marković, Ljiljana Milić Marković, Nikola Gvozdović***APPLICATION OF BIM IN THE PROCESS OF MANAGEMENT
OF CONSTRUCTION PROJECTS 1049***Milan Marojević***BIM – FOUNDATION OF DIGITAL TRANSFORMATION
IN CONSTRUCTION INDUSTRY 1057***Dušanka Plazina-Pevač, Milan Trivunić, Igor Peško, Vladimir Mučenski, Željko Jakšić***DEFICIENCIES OF CLASSIC DESIGN IN RELATION TO BIM DESIGN:
EXAMPLE OF MORGAVEL PHOTOVOLTAIC POWER PLANT 1065**

Mirjana Terzić, Igor Peško, Vladimir Mučenski, Milena Senjak Pejić, Dragana Stanojević
MODELLING COMPLEX PREFABRICATED STAIRCASE USING BIM TOOLS .. 1073

Jelena Vilotijević, Dušan Rožič, Milan Kuhta
**ALLPLAN BRIDGE SOFTWARE FOR GEOMETRICAL
AND ANALYTICAL MODELING OF KOZARICA BRIDGE 1081**

EDUCATION IN CIVIL ENGINEERING 1089

Cristina Campian, Camelia Negrutiu, Maria Pop
**EUROPEAN UNIVERSITY OF TECHNOLOGY – A NEW APPROACH
IN TEACHING THE TECHNOLOGY IN EUROPE 1091**

*Aleksandar Milajić, Dejan Beljaković, Zorica Milovanović Jeknić,
Lejla Vujičić, Kaltom Benansera*
**DEVELOPING STUDENTS' EVALUATION SKILLS
IN REINFORCED CONCRETE STRUCTURES DESIGN 1097**

Biljana Šćepanović, Branka Živković
ENGLISH LANGUAGE IN CIVIL ENGINEERING 1105

Jovana Topalić Marković, Dijana Đurić, Nenad Ivanišević, Vladimir Mučenski, Igor Peško
**SIGNIFICANCE OF COURSES ON CONSTRUCTION LEGAL REGULATIONS
IN THE CURRICULUMS OF FACULTIES OF CIVIL ENGINEERING 1111**

GNP 2022 AUTHORS 1121

PROFESSOR ARSENIJE VUJOVIĆ FOUNDATION 1153

CO-ORGANISER 1157

SPONSORS 1165



**THE 8th INTERNATIONAL CONFERENCE
"CIVIL ENGINEERING – SCIENCE AND PRACTICE"**

GNP 2022 – Kolašin, Montenegro, 8-12 March 2022

Riste Ristov¹, Ivona Nedevska², Zlatko Zafirovski³, Slobodan Ognjenovic⁴, Vasko Gacevski⁵

MEASURES TO IMPROVE SAFETY ON EXISTING MAIN STREET 101

Abstract

Identifying and classifying accident black spots on urban roads is a critical element of road safety research.

An accident blackspot treatment program is a safety improvement program that can reactively deal with accidents. However, implementing such a program requires relevant accident data, which are generally unavailable or limited in developing countries. Thus, this paper proposes a supportive approach (public participation) to overcome this hindrance.

Residence can identify locations where accidents occurrences are unusually high, and their input is potentially helpful for the identification process. In addition, besides the indirect benefits to creating public awareness, the proposed methodology is potentially helpful for speeding up and economizing the accident spot locations identification process. Finally, the paper proposes various construction and traffic safety measures to improve safety.

Keywords

Road safety, accident black spot, construction measures, traffic measures, accidents.

¹ Riste Ristov, MSc, Teaching Assistant, ristov@gf.ukim.edu.mk

² Ivona Nedevska, MSc, Teaching Assistant, nedevska@gf.ukim.edu.mk

³ Zlatko Zafirovski, PhD, Associate Professor, zafirovski@gf.ukim.edu.mk

⁴ Slobodan Ognjenovic, PhD, Associate Professor, ognjenovic@gf.ukim.edu.mk

⁵ Vasko Gacevski, MSc, Teaching Assistant, gacevski@gf.ukim.edu.mk

1. INTRODUCTION

Frequent traffic accidents of a recurring nature occur in the case over a long period. In addition to the accidents between the participants in the traffic on the defined move, most often caused as an additional problem is damage to the surrounding public and private properties.

Requested by residents of this location and with the mediation of the Municipality of Volkovo, an initiative was launched to improve the safety of traffic participants.

The solution envisaged to improve the safety of this section includes a construction and traffic approach. The causes will be defined first, a gradation from more difficult to more straightforward cases, and their solution will be approached.

2. EXISTING CONDITION

The section that is being developed is located in the Municipality of Volkovo on the main street 101 near the railway in a length of about 500m. The scope includes three surface junctions and ten direct connections to the main street. On the horizontal plan, the axis consists of three directions and one "S" curve with radii of about 120 and 80m. An additional problem that impairs traffic safety is the two bus stops, opposite each other, for which, although no niches have been made, they are not correctly marked for traffic.

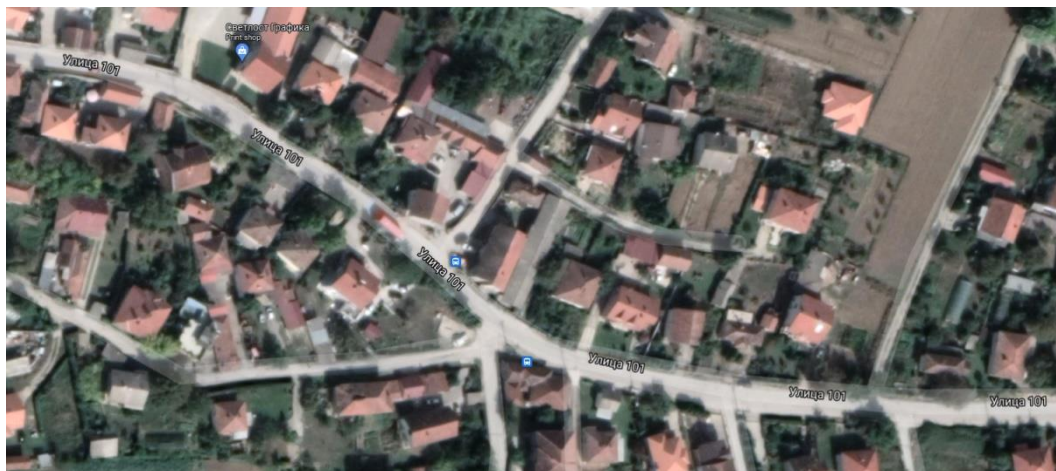


Figure 1. Location of the street

The street is formed with 2-3 minimal violations in the longitudinal profile with a longitudinal slope of about 2-3%.

The street profile consists of two traffic lanes with a width of 2.75 m (total 5.5 m) without sidewalks or a defined pedestrian belt. In the road profile from the side, there are poles for electricity and telephony and distribution boxes for the same at the height of about 1.3 m.

The pavement surface is damaged and does not have a suitable transverse slope corresponding to the horizontal radii.



Figure 2. Existing condition of the street

This section has no drainage elements (maintenance holes with grids or gutters), and all the surface water flows into the surrounding yards.

The lighting of the section is too dim, and in some places, it is covered by the nearest trees.

3. OBSERVED TRAFFIC ACCIDENTS

Due to the lack of data on traffic accidents from the Ministry of Interior and relevant institutions, a survey was conducted of the population living near the location in question, and the following accidents were identified that occurred in two years:

- Accidents from a head-on collision, around 5,
- Rear collision accidents, around 4,
- Side accident, around 7,
- Accidents with injured pedestrians, around 3,
- Accidents with flying off the road towards buildings, 5.

Fortunately, no deaths have been reported so far.

4. MEASURES TO IMPROVE SAFETY

Measures to improve safety can be classified as construction and traffic measures or a combination of both.

4.1. CONSTRUCTION MEASURES

The construction measures that will be applied for all types propose a standard solution of the road structure, according to the number of heavy load axes (and there are many of them) and the application of road structure with coarse fractions and a load-bearing layer of eruptive origin

that will allow greater friction and longevity of the road structure. Also, with the construction approaches, a detailed drainage solution is proposed through the organization of the slopes and the installation of point receivers to reduce the length of the water flow and prevent the occurrence of aquaplaning.

4.1.1. Construction measures outside the border of the regulatory line

These measures are a general approach because they dictate a kind of reconstruction or new planning of the axle and the geometric transverse profile of the road, according to the speed defined for this section. According to the standards, regulations, and guidelines for this type of road, a traffic street with two traffic lanes corresponding to a calculated speed of 40 km / h can be applied [1].

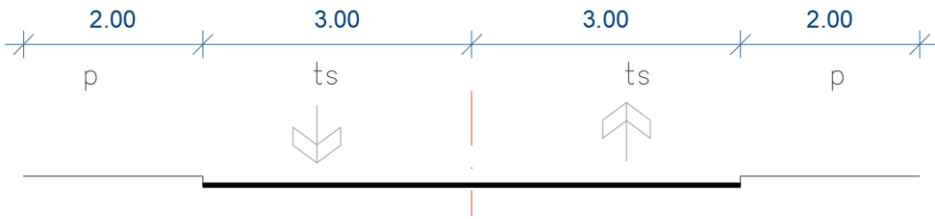


Figure 3. Geometrical cross section of proposed street (outside of the regulatory line border)

The street axis will be minimally reduced, and the predicted future traffic dynamics will define precise transition curves. The visibility will be checked in the horizontal plan, and all obstacles in the visibility zone or the visibility triangle at the intersections will be moved or removed [2].

As it is the main street with a significant number of pedestrians, a solid profile of pedestrian paths is proposed, on both sides of the street, with additional space for placing candelabras, dislocated poles, and other service equipment of the municipality. In addition, it is necessary to make appropriate bus stops at post-cruise locations. The same places will be appropriately marked and lit.

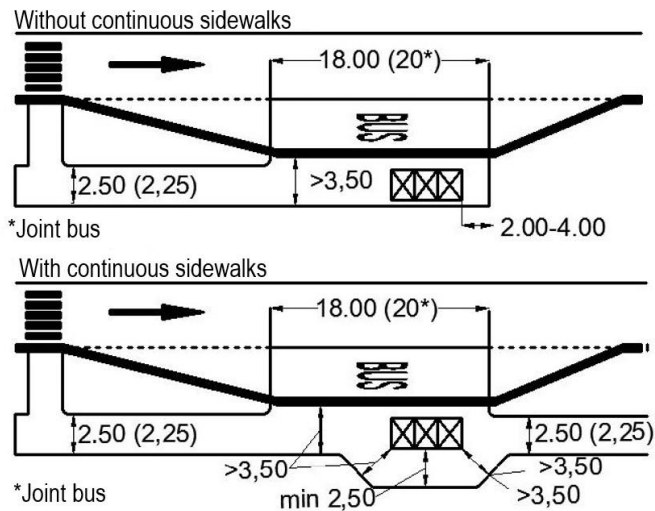


Figure 4. Opening niches for bus stops

Of course, this approach to reconstruction is the most rigorous and to the most significant detriment of the surrounding population because private plots are expropriated. However, it is the safest solution on the planned road.

4.1.2. Construction measures within the border of the regulatory line

These measures include minimal correction of the axis and adjusting the typical cross-section within limits as per the regulation line.

Here, a standard road profile can be envisaged with a minimum lane width and a small sidewalk width only and a buffer curb on the other side (existing solution) due to the constraints defined by the construction scope.



Figure 5. Geometrical cross section of proposed street (inside of the regulatory line border)

The rehabilitation that would be done on the road would follow the longitudinal and transverse slopes to a large extent and maintain a generally fixed width of the cross-section along the entire section [2].

These corrections propose removing or dislocating the existing municipal contents, such as candelabra and service equipment, cables, outside the pedestrian zone, and their eventual placement in the sidewalk zone [3].

4.2. TRAFFIC MEASURES

These measures include horizontal and vertical signaling of three types, namely:

- Traffic signalization of extended construction profile,
- Traffic signalization of construction profile within the limits of construction scope (rehabilitation) and
- Traffic signalization of an existing solution (without construction works).

4.2.1. Traffic signalization of extended construction profile

This measure includes standard traffic signals with particular attention to speed limits, pedestrians' regulated movement, and their protection and definitive formation of bus stops in niches.

4.2.2. Traffic signalization of construction profile within the limits of construction scope

This solution gives a more rigorous approach to protecting pedestrians and their clear direction from the bus stops to the pedestrian paths and vice versa. In addition, the traffic visibility of the pedestrian zones is regulated with reflective traffic signalization.



Figure 6. Bus stop on existing carriageway

Because the bus stops are on the street and cover a large area, it is necessary to double log them back with vertical signalization and setting ramps to reduce speed.

The entire length of this section should be marked with a solid line, which will limit the overtaking of vehicles in both directions[4].

4.2.3. Traffic signalization of an existing solution

Although this measure is the cheapest from a construction aspect, it is the most expensive in terms of traffic because all possible measures and traffic approaches will be applied here to increase the visual visibility, and thus the safety of traffic participants.

The first measure that is applied is the speed limit with vertical signalization of 40 km/h. Together with this measure, the overtaking of vehicles is limited. In both directions of movement, at the beginning and the end of the section, it is planned to set announcement vibrating lines, and after them at 50m in front of the bus stops to set up calming ramps intended only for cars.



Figure 7. Vibro lines



Figure 8. Calming ramps for cars

In addition, due to the reduced visibility, convex mirrors will be provided on both sides of the curve, which will enable the perception of a possible collision of vehicles from the opposite direction and the connection of vehicles from neighboring intersections and buildings.



Figure 9. Convex mirror

At the road's edges, it is advisable to place high reflective poles on both sides to protect pedestrians moving on the buffer paths.



Figure 10. High reflective poles

In the middle of the road, on the white line at a distance of 5 m to place reflective signs that will have a dual function, visual display of the lane, and vibrating warning for a possible exit from the traffic lane[4].



Figure 11. Reflective badges

5. CONCLUSION

The scope section is a black spot related to the earlier traffic accidents. However, it is not unique. Such locations on municipal roads throughout Macedonia are many and are little treated. At least on the main roads, it is advisable to make similar analyses by defining the number of accidents and preparing appropriate documentation to improve and overcome such problems. When making such analyzes, the solutions should always be sublime from a construction and traffic aspect so that a more expedient solution towards a better level of service can emerge.

The standard design of streets in rural areas usually covers these measures, but this design may never happen. For this reason, it is necessary to take the initiative for their early detection.

It should be considered that smaller municipalities do not always have the necessary staff to recognize these problems. In such cases, it is advisable to inspect such sections by the competent authorities at the regional level, which specifically treat only the safety of the roads.

LITERATURE

- [1] Maletin M., 2009, Planiranje i Projektovanje Saobraćajnica u Gradovima
- [2] Ministry Of Transport and Communications, 2009, Rulebook for technical elements for construction and reconstruction of public roads and road facilities
- [3] Public Enterprise of State Roads, RNM, 2016, Road Safety Audit Manual
- [4] Ministry Of Transport and Communications, 2020, Rulebook for traffic signs, equipment and road signaling