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CONSTRUCTION WASTE MANAGEMENT PLAN FOR REHABILITATION OF THE ĐURĐEVIĆA TARA BRIDGE

Abstract:

The rehabilitation and reconstruction of the Đurđevića Tara Bridge, a structure of national importance, located within a protected area, the UNESCO Biosphere Reserve, inevitably generates various types of construction waste. This paper presents the waste management approach, focusing on the identification, source separation, temporary storage, and transport of inert and hazardous waste. The plan emphasizes minimizing the impact on the sensitive Tara Canyon ecosystem, promoting recycling and the exclusive use of authorized operators for disposal. However, the plan relies on local capacity and digital systems assumptions; failure risks environmental contamination and legal penalties.

Keywords: construction waste management, bridge rehabilitation, environmental protection

ПЛАН УПРАВЉАЊА ГРАЂЕВИНСКИМ ОТПАДОМ ТОКОМ САНАЦИЈЕ МОСТА ЂУРЂЕВИЋА ТАРА

Сажетак:

Рехабилитација и реконструкција моста Ђурђевића Тара, грађевине од националног значаја смештене у заштићеном подручју –УНЕСКО резервату Бисфере – неизбежно генерише разне врсте грађевинског отпада. Овај рад представља приступ управљању отпадом, фокусирајући се на идентификацију, изворно раздвајање, привремено складиштење и транспорт инертног и опасног отпада. План наглашава минимизирање утицаја на осетљиви екосистем кањона Таре, промовишући рециклажу и искључиву употребу овлашћених оператера за збрињавање. Међутим, план се ослања на претпоставке о локалним капацитетима и дигиталним системима; неуспех носи ризик од загађења животне средине и правних санкција.

Кључне речи: управљање грађевинским отпадом, реконструкција моста, заштита животне средине

1. INTRODUCTION

The construction sector is one of the key global economic sectors; however, it is also among the largest generators of waste. Construction and Demolition Waste (CDW) encompasses a heterogeneous group of materials that are generated during the construction, reconstruction, renovation (adaptation), and demolition of buildings and infrastructure. According to available estimates, the construction sector in the European Union generates over 850 million tonnes of waste annually [1] and construction and demolition waste constitutes about 40% of all waste in the EU [2]. The Waste Framework Directive 2008/98/EC [3] and the Landfill Directive 1999/31/EC [4] also regulate the field of construction and demolition waste management, thereby promoting the transition towards a circular economy in construction.

Montenegro is facing challenges in adapting to European standards in the field of environmental protection, particularly in waste management – standards based on the principles of the circular economy. By adopting the new Law on Waste Management [5], Montenegro has established a modern regulatory framework largely aligned with European directives. This law mandates the separation of construction waste by material categories and sets ambitious recycling targets for 2030. It stipulates that by 2030, preparation for reuse, recycling, and other forms of material recovery, including backfilling operations where waste substitutes other materials, must account for at least 70% of the mass of collected non-hazardous construction waste, excluding naturally occurring material (waste code 17 05 04). According to MONSTAT data [6] for the period from 2016 to 2023, the share of construction waste in Montenegro's total waste ranged from 13% to 31%, averaging about 19%. In the same period, the recovery rate of construction waste ranged from 0.3% to 33.8%, averaging about 16.5%. These figures are particularly concerning when compared to the EU average, where the recycling rate for construction waste exceeds 70%. This situation indicates systemic problems in construction waste management.

The waste management hierarchy established by the Waste Framework Directive establishes a priority order from the most to the least desirable option: (1) prevention, (2) preparation for reuse, (3) recycling, (4) other recovery (e.g., energy recovery), and (5) disposal (eur-lex.europa.eu) (Figure 1). By incorporating this hierarchy into national legislation, it becomes an operational framework for all actors in the waste management system, including construction waste producers.

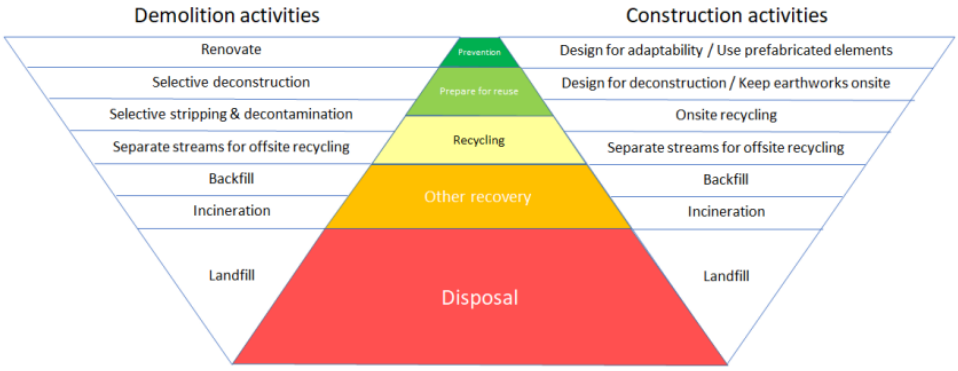

Figure 1. Linking the EU waste hierarchy to construction and demolition activities [7].

While the mentioned EU directives do not explicitly require waste producers to create their own waste management plans, they establish a framework that indirectly obliges them to plan and organize the management of their waste in accordance with the principles set out in the directives. These principles are then specified and enforced through national legislation. In this context, Montenegrin law stipulates, among other things, that producers of construction waste are obligated to develop a construction waste management plan if the volume of the structure, including earth excavation, exceeds 2,000 m³, or if the construction waste contains or is exposed to hazardous materials, regardless of the structure's volume.

This provision aims to ensure that construction waste management is not ad hoc but is instead deliberate and planned, at least for more complex projects. Developing a construction waste management plan does not exempt the contractor from any provision of the Waste Management Law, including obligations related to waste identification and segregation, record-keeping, strict

monitoring (especially of hazardous waste), and the key requirement to hand over waste exclusively to an authorized entity.

The content of a construction waste management plan is defined by the Waste Management Law and the Rulebook on construction waste management [8]. Its content is the same whether it is prepared for the construction of a new building, or for the demolition or reconstruction of an existing one.

The aim of this paper is to present and critically analyse a construction waste management plan developed for the rehabilitation of the Đurđevića Tara Bridge, with particular emphasis on regulatory compliance, waste characterization, and practical implementation challenges in environmentally sensitive areas.

2. PROJECT CHARACTERISTICS AND SCOPE OF REHABILITATION

The Đurđevića Tara Bridge (Figure 2) is a reinforced concrete arch bridge spanning the Tara River canyon at a height of approximately 150 meters above the riverbed [9]. Constructed in the mid-20th century, it represents a vital transport link in northern Montenegro, located over the Tara River near the village of Budečevica at the junction of regional road R10 and main road M6. The project for the bridge's reconstruction is the result of an initiative by the People's Republic of China and a subsequent implementation agreement signed with the Government of Montenegro, securing an investment of approximately 7.2 million euros. The works are structured in two phases: the first phase encompasses the rehabilitation and reconstruction of the bridge structure itself, while the second phase includes the reconstruction of the approach roads. The Institut za građevinarstvo d.o.o. from Podgorica played a key role in the project's design phase, acting as a subcontractor responsible for developing both the preliminary and main designs. The Institute also served as the coordinator for design progress and provided consulting activities throughout.

Since its original construction, the bridge has endured severe climatic conditions, significant temperature fluctuations, freeze-thaw cycles, and increasing traffic loads. This exposure has led to progressive deterioration of its concrete elements, waterproofing, bearings, and safety equipment. Given its critical role in regional connectivity and its status as a cultural and touristic landmark, the rehabilitation required meticulously planned construction organization and technology.

Figure 2. Đurđevića Tara Bridge [9].

The total length of the bridge is approximately 366 m, with a roadway width of 7.0 m consisting of two traffic lanes and narrow pedestrian walkways. Structurally, the bridge is composed of a main reinforced concrete arch with a span of 116 m and approach structures. The approach structure towards Žabljak, i.e. Mojkovac, was designed as a viaduct with four arches of 44.08 m span for each, and a connecting continuous beam structure over two spans of 17.00 m each.

The measures outlined in the Main Design are based on the Elaborate on the Existing Condition of the Bridge and the Preliminary Design for its reconstruction. They comply with all relevant requirements, including the Urban-Technical, Conservation, and Traffic Conditions, the Project Terms of Reference, and the specific Conservation Conditions.

These measures include [9]:

- Strengthening the existing roadway by adding a layer of micro-reinforced concrete;

- Strengthening the longitudinal main and transverse beams by adding reinforcement in the upper zone of the beams;
- Installing a new MMA waterproofing and a 5 cm thick asphalt overlay;
- Removal of existing and installation of new pedestrian paths with prefabricated curbs and PVC pipe installation;
- Removal of existing and installation of new granite curbstones;
- Rehabilitation of the existing concrete guardrails and steel pipes;
- Removal of existing drains and installation of new drains;
- Installation of asphalt expansion joints;
- Reconstruction of bearings;
- Rehabilitation of local damage to concrete elements by type of damage;
- Rehabilitation of significant local damage to unreinforced main columns and foundations;
- Injection of cracks wider than 0.15mm;
- Strengthening other structural elements lacking sufficient load-bearing capacity with carbon strips and fabric, as well as structurally strengthening the lower zone of the bridge deck with carbon strips.
- Construction of newly designed transition plates 3.5m in length on both sides of the bridge;
- Strengthening the foundations under pier "A";
- Rehabilitation of stone guardrails;
- Landscaping in the bridge area, clearing shrubbery, and site cleaning.

In addition to these measures, electrical installations and systems are planned for functional and decorative lighting of the bridge: low-voltage cable lines, main distribution cabinet, cable supports, roadway functional lighting installations, bridge decorative lighting installations, grounding and potential equalization installations.

3. ENVIRONMENTAL PROTECTION PROCEDURES CARRIED OUT

The bridge location is situated within the area of the "Durmitor" National Park. Durmitor National Park was established in 1952 and has been on the UNESCO World Heritage List (Natural and Cultural) since 1980. This area encompasses exceptionally rich biodiversity – over 1,300 plant taxa have been registered, of which 122 species are of an endemic character. Durmitor is also included in networks of protected areas, including the Emerald Network and IPA (Important Plant Area). Furthermore, the Tara River Canyon was declared a World Biosphere Reserve in 1977 through the UNESCO "Man and the Biosphere" (MAB) program, confirming its global ecological value.

All of this highlights the exceptional significance of the area where the bridge and access road reconstruction is planned, and requires the highest level of attention and precaution.

In accordance with this and with the applicable environmental protection regulations and the potential impacts of construction activities, the project proponent submitted a request [10] for a decision on the need to prepare an Environmental Impact Assessment (EIA) report. The goal of the procedure was to ensure that, through expert assessments, all critical aspects of environmental protection are considered in advance during the project planning phase. The focus of the potential significant impacts was on identifying and analyzing risks to the sensitive ecosystem of Durmitor National Park during the planned reconstruction.

It was determined that, with the application of the proposed precautionary measures, most environmental components would remain preserved. It was assessed that there should be no significant threat to the water quality of the Tara River, the geological values of the area, nor any permanent impact on rare and protected plant and animal species. On the other hand, the document highlighted certain segments where impacts during construction were considered certain, albeit temporary. This primarily related to the local deterioration of air quality due to dust and emissions, and to the exceeding of permitted noise levels in the immediate vicinity of the construction site. The greatest potential risk identified was the possibility of accidental pollution, such as fuel spills, which could threaten soil and surface water.

Evaluating these assessments, as well as the proposed protection measures, and in accordance with the Regulation and Laws, it was determined that the preparation of an Environmental Impact Assessment report was not necessary [11]. However, specific environmental protection measures were prescribed for the construction and operational phases. Given that construction machinery is the primary source of potential impacts during the construction phase (emissions, noise, possible oil and fuel leaks), the majority of the prescribed measures are directed at its use. These measures

include the use of equipment meeting specific emission EU standards, mandatory maintenance, and measures to prevent dust and leaks, among others. Furthermore, the measures foresee the reduction of soil loss and damage, and the protection of biodiversity by selecting locations that were previously degraded or already occupied/built-up for the purpose of disposing of construction and other waste material, temporary parking, and the maneuvering of construction machinery.

The decision issued by the Environmental Protection Agency guarantees that, although the preparation of a formal impact assessment was not mandatory, the project will be implemented with strict adherence to all necessary ecological standards and protective measures, adapted to the specific sensitivity of the location.

One part of the defined measures pertains to waste, primarily the obligation of the contractor to prepare a Construction Waste Management Plan and obtain approval for it from the competent authority in accordance with the law. Other waste-related measures are incorporated into the Waste Management Plan in a next chapter.

4. CONSTRUCTION WASTE MANAGEMENT PLAN

According to Article 54 of the Waste Management Law [5] and Article 5 of the Rulebook on construction waste management [8], producers of construction waste generated from a structure with a volume exceeding 2,000 m^3 are required to develop a construction waste management plan.

The total volume of excavation for Phase 1 is 100 m^3 while the total quantity of material generated by demolishing existing asphalt and concrete elements is 300 m^3. Accordingly, a Construction Waste Management Plan is not required. Nevertheless, elements of the plan are provided here, as required by the Terms of references and decision issued by the Environmental Protection Agency [11].

The content of the plan is defined by Article 27 of the Waste Management Law and Article 5 of the Rulebook. Based on this, the plan must include information about:

- the type, quantity, and location of the generation of various types of construction waste, in accordance with the waste catalog,
    - estimated volume of earth excavation resulting from construction work at the construction site and the handling thereof,
    - estimated volume of earth excavation used on the construction site that did not result from construction work at the site.
- the period during which procedures or activities resulting in waste production will be carried out
- measures to prevent waste production or reduce waste quantities and its negative impact on the environment
- waste management methods, including collection, temporary storage (location), transport, and waste treatment,
    - method of separating hazardous construction waste before the removal of the structure if structure removal is planned,
    - method of separate collection of construction waste at the construction site,
    - method of construction waste treatment at the construction site.

4.1. TYPES AND QUANTITIES OF CONSTRUCTION WASTE

Construction waste expected to be generated during the implementation of this phase can be categorized into basic groups on-site:

- Homogeneous construction waste with easier technical and technological reusability or recycling, with recycled materials being technically applicable without significant limitations:
- Mixed construction waste with complex technical and technological reusability, and recycled materials are technically applicable with predefined limitations.

In addition, from the detailed description of the works and the bill of quantities it can be seen that, for part of the rehabilitation works, certain chemical products are also used, such as epoxy resins, adhesives, coatings, mortars, as well as waterproofing systems based on Methyl Methacrylate (MMA), silane- and acrylate-based coatings. These materials, in their original supplied state, represent hazardous substances, while after application and curing they lose their hazardous properties. However, their unused residues, packaging, and tools that have come into contact with them must be treated as hazardous waste.

Hazardous construction materials are typically supplied in standardized industrial packaging, the residues and contaminated packaging of which must be classified and managed as hazardous waste in accordance with SDS instructions and applicable legislation.

Table 1 summarizes the estimated quantities and types of construction waste generated during Phase 1 of the project.

Table 1. Estimated quantity of waste

Type of construction waste, in accordance with the waste catalog	Estimated quantity	Location of generation
17 01 Concrete, Bricks, Tiles, and Ceramics		
17 01 01 Concrete	(175.7 m3) 450.00 t	on the bridge during the demolition of existing pedestrian paths, sidewalks, and other concrete elements
17 02. Wood, glass and plastic		
17 02 03 Plastic	0.10 t	construction site, during installation of PE pipe as an extension to the approved drain
17 03 Bituminous Mix, Tar, and Tar-Containing Products		
17 03 02 Bituminous Mixes other than 17 03 01*	(124.0 m3) 300.00 t	on the bridge during the demolition of the existing road structure
17 04 Metals (including their alloys)		
17 04 05 Iron and Steel *Reinforcement debris and old iron drain*	(600 kg) 0.60 t	at the reinforcement manufacturing locations (in case reinforcement manufacturing facilities are organized on the construction site), estimated as leftover reinforcement from cutting, which is not usable (estimated at 1%)
	0.20 t	on the bridge during the demolition of the Existing iron drain DN110
17 04 11: Cables other than those mentioned in 17 04 10*	(500 m) 0.25 t	construction site, tailoring and installation of cables for electrical installations of the bridge
17 05 Soil, Stone, and Excavated Sludgy Waste		
17 05 04 Soil and Stone other than 17 05 03*	(96.7 m3) 200.00 t	at excavation sites for pillar reinforcement and electrical installations
15 Waste packaging; absorbents, wiping cloths, filtering materials, and protective clothing, not otherwise specified		
15 01 01 paper and cardboard packaging 15 01 02 plastic packaging 15 01 06 mixed packaging *Completely clean, dry packaging*	0.20 t	construction site
15 01 10* – Packaging containing residues of or contaminated by hazardous substances	0.65 t	construction site
15 02 02* – Absorbents, filter materials, wiping cloths and protective clothing contaminated by hazardous substances	0.15 t	construction site
08 01 – Wastes from MFSU of paint and varnish		
08 01 11* – Waste paint and varnish containing organic solvents or other hazardous substances	0.10 t	construction site (*Residues of MMA (primer, membrane) and residues of silane inhibitor (Sikagard-706)*
08 01 21* – Waste paint or varnish remover	0.10 t	construction site (*Residues of all epoxy products (Sikadur all other)*
20 Municipal waste (household waste and similar commercial and industrial waste), including separately collected fractions		
20 03 01 – Mixed municipal waste	13.00 t	construction site
Total non-hazardous waste	**964.00 t**	
Total hazardous waste	**1.00 t**	
TOTAL WASTE	**965.00 t**	

These types of waste must be collected and stored separately in dedicated containers before being handed over to commercial companies or entrepreneurs responsible for waste processing or disposal within the municipality of Pljevlja, in accordance with legal regulations.

The expected types of construction waste fall mainly into the category of non-hazardous, inert waste. Based on these estimates, the approximate general composition of the most abundant construction waste in this project is as follows:

- Earth material (excavation) 20.7%
- Asphalt rubble 31.1%
- Concrete rubble 46.6%

The project foresees that the contractor will load and transport the excess excavated material (in this case, the total quantity) to the location designated by the municipality of Pljevlja for the disposal of non-hazardous construction waste (location Jagnjilo). If local government units do not have established facilities for processing construction waste and facilities for the disposal of non-hazardous construction waste and/or an inert waste landfill in accordance with the law, the material should be taken to a temporary storage location for non-hazardous construction waste in accordance with Article 78a of the Law.

4.2. PERIOD OF WASTE GENERATION

According to the dynamic schedule within the Design organization and technology [9], the implementation of this project phase is estimated to take approximately 16 months. Considering the climatic conditions that significantly impact construction, the most favorable period for the execution of works would be from mid-February to December.

The preliminary project schedule, prepared in MS Project using a network schedule to identify critical activities and control progress, spans approximately 260 working days (16 calendar months) from February 2024 to June 2025, followed by load testing and technical inspection.

The precise plan and construction deadlines will be defined after the selection of the contractor and the signing of the construction contract.

4.3. MEASURES TO REDUCE WASTE AND ENVIRONMENTAL IMPACT

The fundamental principle to be followed in waste management is to minimize the amount of disposed waste, utilizing everything that can be repurposed for useful purposes. While waste prevention is preferable, it is often unavoidable. Measures to prevent waste production and mitigate its negative impact are partially defined by technical documentation and partially fall within the responsibility of the contractor. Monitoring is required to ensure the implementation of these measures.

Measures defined in technical documentation include:

- The planned scope of concrete and asphalt demolition is conditioned by urban-technical and conservation requirements on one hand and the technical characteristics of the rehabilitation and reconstruction solution on the other.
- The installation of materials whose remnants do not fall under the hazardous waste category is foreseen.
- The installation of materials that can be recycled (concrete, asphalt, reinforcement) and a negligible portion of materials that cannot be recycled (waterproofing).
- Proper waste management in accordance with the Waste Management Law.

Measures within the contractor's responsibility relate to the organization of technological processes used on the construction site. This includes:

- Inspection and potential testing of excavated material to determine its suitability for on-site use.
- Efficient use of reinforcement to reduce damage, the need for recutting, and waste during cutting:
    - Creating optimal reinforcement cutting plans.
    - Proper storage at a safe distance from the ground to protect against corrosion.
    - Correct bundling and labeling with tags.
    - Stacking near the installation site following the installation sequence.
    - Continuation of reinforcement through welding or mechanical means, in accordance with technical regulations.
- Rational and efficient use of machinery to avoid breakdowns that could lead to fuel and lubricant pollution:
    - Proper selection of equipment according to the required capacity and machine power.

  - Ensuring proper maintenance, with minor maintenance performed on-site and major maintenance carried out at machinery bases.
  - Selection and training of machine operators.
- Organizing technological processes for the demolition of structures or their elements to minimize noise, dust, and air pollution.

4.4. WASTE COLLECTION, STORAGE, TRANSPORT AND TREATMENT

Waste management planning for construction begins as early as the project's preparation phase, often during the design phase. During this phase, opportunities to reduce waste can be identified, and a bill of quantities and a cost estimate that also takes waste disposal into account can be prepared.

The primary objectives of construction waste management are as follows:

- Minimizing and preventing the generation of construction waste.
- Separating construction waste at the point of generation and collecting it, including packaging waste.
- Reusing and/or recycling construction waste.
- Using materials from excavation and crushed materials as backfill, etc.
- Disposing of construction waste at construction waste disposal sites such as quarries, landfills, inert waste disposal sites within regional landfills, or specially established disposal sites, or planned disposal of inert material at temporary disposal sites along road construction routes, disposal at sanitary landfills for daily waste cover, etc.
- Reducing the permitted quantities of construction waste that are disposed of at regulated waste disposal sites.
- Separating and disposing of all types of construction waste that contain hazardous substances separately.
- Implementing specific activities for the collection and disposal of materials containing asbestos, PCBs, mercury, and other hazardous substances, and their disposal in accordance with legal regulations for hazardous waste disposal.

Designing buildings with a high percentage of recyclable materials achieves the first principle of waste management hierarchy, which is waste prevention. Specifically, when demolishing or reconstructing buildings with a high proportion of recyclable materials, only small quantities of non-usable waste are generated, while the vast majority can be reused. This is the fundamental way to prevent the production of construction waste.

4.4.1. Method of separate collection, temporary storage (location), transportation, and processing of construction waste on the construction site

The Waste Management Law defines, in particular, the following:

- Disposing of construction waste into water bodies, land, or soil is prohibited unless the construction waste is processed and used as a construction material.
- Generated waste must be classified according to origin (waste catalogue), category (waste list) and character.
- Mixing different types of waste is strictly prohibited
- Construction waste may be temporarily stored within the area of the construction site for which a building permit has been issued. This storage is permitted only until the completion of construction works, for a maximum period of one year. In any case, all construction waste must be removed prior to the Final Technical Inspection of the building.
- Construction waste that does not contain hazardous substances and cannot be processed is disposed of at an inert waste landfill.
- The contractor should keep records on the type and amount of construction waste on a monthly basis.
- The contractor draws up a construction waste management plan approved by the competent authority in accordance with the law.

To prevent water and soil pollution due to improper storage and handling, the Contractor needs to:

- Properly organize and cover material storage areas.
- Dispose of waste materials in suitable locations protected from runoff.
- Ensure proper handling of lubricants, fuel, and solvents to protect against environmental soil contamination.

In addition, measures from the Decision of the Environmental Protection Agency prescribe the following:

- It is not allowed to deposit any kind of waste materials on the wider construction work area.
- For the purpose of temporary storage of construction and other waste material, use previously disturbed areas on the construction site or in its vicinity.
- Deliver all remaining waste materials that have a usable value to companies authorized for the collection, transport and processing of secondary raw materials, along with the completion and certification of documents on the transportation of waste.

Based on the expected types of construction waste, the following methods for the collection, temporary storage, transportation, and processing of identified waste are planned (Table 2).

Table 1. The waste management methods for the most common and dangerous waste Type of Waste (EWC Code)

Collection	Temporary Storage	Transport	Waste Treatment on Construction Site
17 01 01 Concrete			
Mechanical demolition using jackhammers, pneumatic hammers, and excavators.	Not planned. Material will be directly loaded onto trucks following demolition.	Transport by covered trucks by a licensed waste carrier. Material will be delivered to an authorized waste processor.	No on-site treatment. Waste will be handed over to a licensed facility for crushing/recycling.
17 03 02 Bituminous Mixes (non-hazardous)			
Removal of existing asphalt layers using milling machines, jackhammers, and excavators as per project design.	Not planned. Material will be directly loaded onto trucks following removal.	Transport by covered trucks by a licensed waste carrier. Material will be delivered to an authorized waste processor.	No on-site treatment. Material will be sent for recycling (RAP - Reclaimed Asphalt Pavement).
17 04 05 Iron and Steel			
Includes reinforcement off-cuts from resizing/cutting and replaced old iron gullies.	Small quantities will be stored in a container on-site until collection by an authorized waste collector.	Transport by trucks operated by a licensed waste carrier. Material will be delivered to an authorized metal scrap collector.	No on-site treatment. Waste will be prepared for off-site smelting/recycling.
17 04 11 Cables (non-hazardous)			
Collection of cable off-cuts and wiring residues upon completion of electrical installation phases.	Temporary storage in designated bins or containers for non-hazardous metal, until collection by an authorized waste collector	Transport by a licensed waste carrier to an authorized facility for cable stripping and metal recovery.	No on-site treatment. Separation of copper/aluminum from insulation will be done off-site.
17 05 04 Soil and Stone (non-hazardous)			
Mechanical excavation using excavators and backhoes.	Not planned for waste portion; soil is immediately loaded for transport.	Transport by trucks to the designated inert waste landfill (as specified by the Pljevlja municipality).	On-site reuse: Suitable material will be used for backfilling and site leveling as per project requirements.
15 01 10* Packaging containing hazardous residues			
Collection of empty canisters/drums of MMA, silane inhibitors, and epoxy resins immediately after use.	Stored in a designated, secured hazardous waste area. Canisters must be closed to prevent vapor release.	Transport by a licensed hazardous waste carrier in compliance with ADR regulations.	No on-site treatment. Containers will be sent to an authorized facility for chemical cleaning or incineration.
15 02 02* Contaminated absorbents, cloths, and PPE			
Collection of used brushes, rollers, wiping cloths, and protective gloves contaminated with chemicals.	Stored in leak-proof UN-certified drums or specialized containers within the hazardous waste storage area.	Transport by a licensed hazardous waste carrier under ADR standards.	No on-site treatment. Waste is delivered to an authorized facility for hazardous waste incineration or landfilling.
08 01 11* Waste paint/varnish (MMA and Silane residues)			
Collection of liquid residues of MMA (primer, membrane)	Stored in original canisters or UN-certified drums placed	Transport by a licensed hazardous waste carrier. Electronic Waste Transfer	No on-site treatment. Residues will be handed over to an

and silane inhibitors (Sikagard-706).	on spill pallets (secondary containment).	Notes (e-WTN) are mandatory.	authorized facility for chemical treatment or recovery.
08 01 21* Waste paint or varnish remover (Epoxy residues)			
Collection of residues from all epoxy products (Sikadur series) and any used cleaning solvents.	Stored in clearly labeled, sealed containers on spill pallets to prevent soil or water contamination.	Transport by a licensed hazardous waste carrier only. ADR-certified vehicle and driver required.	No on-site treatment. Material will be delivered to a licensed facility for hazardous chemical disposal.
20 03 01 Mixed municipal waste			
Daily collection of non-recyclable waste from workers' meals and office activities.	Stored in 1.1m³ containers; waste removal is scheduled every two days (bi-daily).	Transport by a local municipal utility company or a licensed communal waste carrier.	No on-site treatment. Waste is transported to a regional sanitary landfill.

All types of inert construction waste that cannot be reused and collected municipal waste should be transported to landfills. The regular collection of collected construction waste should be carried out by the contractor, based on a contractual obligation with the Investor and in collaboration with the competent municipal utility company in the Pljevlja municipality.

In addition to separating construction waste, it is necessary to properly manage and dispose of the non-hazardous packaging waste that accompanies construction materials. The separation, collection, recycling, and reuse of construction material packaging is done through separate collection at the point of origin (on the construction site), and then the packaging waste is handled in accordance with the regulations for that type of waste.

4.4.2. Method for separating hazardous construction waste before demolishing a building, if demolition is planned

To prevent adverse environmental effects, the collection, reuse, disposal, and other activities related to construction waste containing or contaminated with hazardous materials (hazardous construction waste) must be cleaned of harmful substances and/or decontaminated at the point of origin or at the collection site whenever possible, in accordance with relevant regulations and laws.

The occurrence of hazardous waste is not anticipated. However, in the case of accidental situations (e.g., equipment malfunctions or breakages), construction waste contaminated with hazardous materials may appear:

- 13 02 06* synthetic motor oils, gearbox oils, and lubricants (A)
- 15 02 02* absorbents, filter materials (including oil filters not otherwise specified), wiping rags, protective clothing, contaminated with hazardous substances (M)

If hazardous waste materials emerge during the construction of sections and structures, it is necessary to ensure that hazardous construction materials are separated to prevent the mixing of hazardous construction waste with non-hazardous construction waste, if technically feasible. If hazardous waste appears on the construction site, waste should be handed over to a company authorized to collect hazardous waste in accordance with applicable regulations.

The final disposition or treatment of waste categorized as hazardous waste should be ensured by a contract with an operator authorized to manage hazardous waste. This operator will collect and properly transport (convey) the waste to the treatment site and subsequently to the final disposal site.

If construction materials contain a substance or material listed as hazardous waste, such construction materials are separately collected, transported, and stored as hazardous waste. The same approach is applied to contaminated soil from excavation.

5. CONCLUSION: IMPLEMENTATION RISKS AND PROPOSED MITIGATION MEASURES FOR THE WASTE MANAGEMENT PLAN

The Construction Waste Management Plan for the rehabilitation of the Đurđevića Tara Bridge provides a clear and legally compliant framework. However, its effective implementation faces risks stemming from assumptions about infrastructure capacity and logistics, which may prove challenging under Montenegro's real-world conditions. Improper execution carries significant risks, ranging from irreversible environmental damage to the sensitive Tara River Canyon to substantial legal and financial repercussions for the contractor.

To transform the plan from a declarative document into an operational tool and mitigate the identified risks, the following key measures are essential:

- Strengthening logistical and infrastructure resilience: Proactive contracting with multiple operators and verifying processing capacities before work begins will mitigate the risk of delays due to insufficient local capacity.
- Enhancing operational readiness: Increasing on-site temporary storage capacity and establishing strict deadlines with penalty clauses in transport contracts will reduce dependency on external factors and ensure work continuity.
- Escalating protection for the sensitive ecosystem: Mandatory implementation of secondary containment systems for all hazardous waste, along with establishing a clear emergency response plan with trained personnel and equipment on-site, will directly protect the aquatic ecosystem of the Tara River Canyon from potential contamination.
- Ensuring legal compliance through technology: Introducing digital, daily record-keeping and appointing an internal supervisor for documentation audits will eliminate the risk of lapses in waste tracking and enable timely correction of deficiencies.

By implementing these measures, the Plan will gain robustness and become an active risk management tool rather than a static list of procedures. Final success will depend on the consistent application of these measures on the ground, continuous monitoring, and flexibility in addressing unforeseen operational challenges. This approach will achieve the core objective: protecting the unique natural environment and completing the project in full alignment with the principles of sustainable development and the circular economy.

This case study contributes to the understanding of construction waste management in protected natural areas and demonstrates how regulatory requirements can be operationalized within complex infrastructure rehabilitation projects in small EU candidate countries.

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