

Report of RILEM TC 308 PAR: Cold recycling of reclaimed asphalt with bituminous binders – A critical comparison of practices in the countries involved in the TC 308-PAR TG1, Part II

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Abstract

The RILEM technical committee on Performance-based Asphalt Recycling TC 308-PAR is dedicated to advancing research, promoting knowledge exchange, and disseminating information related to asphalt material recycling. Within this framework, Task Group 1 (TG1) “Performance-based Evaluation of Cold Recycled Asphalt Mixtures” concentrates on aligning laboratory testing methods with the real-world performance of cold recycled asphalt mixtures. To this end, TG1 members collaborated to share the various cold recycling practices adopted in their respective countries. This collaboration aimed to compare specific procedures, technical specifications, and expected performance outcomes. The participants diverse backgrounds, spanning differences in road classifications, traffic loads, climatic conditions, and availability of materials, enabled the development of a comprehensive overview of current methodologies and provided insights into the potential expansion of cold recycling applications.

The comparative study of national practices has been structured into two papers: Part I focuses on the constituent materials and mixture composition, while Part II addresses testing protocols and the construction process. In detail, Part II reports a critical comparison of testing procedures, mechanical characteristics, construction methods and quality control procedures used in Italy, Canada, Poland, Brazil and USA, either adopted by selected road administrations or established by reference standards. Accordingly, all initial assumptions, terminology, definitions, and the general context presented in Part I should be considered fully referenced and applicable. This paper focuses on recycling techniques using both cement and bitumen as binders. Conversely, although the use of cement alone is a recognized and widely applied technique, as reported in Part I, Part II does not consider it, since a greater degree of uniformity in procedures and knowledge has already been achieved and shared worldwide.

Keywords: Cold recycling practices; Reclaimed asphalt; Mechanical characteristics; Construction and quality control procedures.

1 Introduction

At present, there is no universally accepted testing procedure for the mechanical characterization, mix design, and quality

control of cold recycled mixtures. As a result, universities, research centers, and road administration agencies have

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developed their own methodologies from their laboratory testing and field experience [1].

Although Cold Central Plant Recycling (CCPR), Cold In-Place Recycling (CIR), and Full-Depth Reclamation (FDR) use different equipment and operational practices, the resulting products exhibit similar physical and mechanical properties. Consequently, testing and laboratory procedures often rely on the same equipment and follow comparable protocols [2][3].

Cold recycling allows the production of a wide variety of mixtures by combining different materials, binders, and dosages. These mixtures are generally classified according to binder content as follows [4]: cement-treated materials (CTM), which use only cement (up to 5%); bitumen-stabilized materials (BSM), which contain less than 1% cement or lime, and up to 2.5% bitumen; cement-bitumen treated materials (CBTM), characterized by higher contents of both cement and bitumen (1-3%).

Binder dosages and combinations produce in mixtures with complex mechanical behavior, different design objectives, and distinct failure criteria. Consequently, tailored approaches are used for the mechanical characterization, mix design, and quality control of cold recycled mixtures.

A key feature that distinguishes cold recycled mixtures from asphalt-like mixtures is the curing process, which plays a crucial role in the development of their mechanical properties [5][6].

The members of TC 308-PAR Performance-based Asphalt Recycling, working on the project entitled "Performance-based evaluation of cold recycled asphalt mixtures" [7], have collected and critically compared the current testing procedures and mechanical characterization of cold recycling for mix design and quality control purposes as applied in their respective countries.

2 Testing procedures and mechanical characteristics

Testing procedures for the mix design and mechanical characterization of cold recycled mixtures vary meaningfully among countries. The choice of testing procedures, which determines the testing equipment and the physical properties to be assessed, is mainly influenced by practical experience, commonly used methods, the availability of laboratory equipment, and the adopted recycling approach and objectives. At one extreme, when the cold recycled mixture is considered similar to an asphalt-like material, a testing approach similar to that used for asphalt concrete is adopted. Conversely, when the cold recycled mixture is considered close to an unbound granular material, concepts and methodologies from geotechnical engineering are adapted.

In the technical specifications for Italian motorway, the volumetric and mechanical properties of the cold recycled mixture must be assessed using a gyratory compactor (GC) under the following conditions: compaction energy of 100 revolutions, internal inclination angle of $1.16^\circ \pm 0.02^\circ$, closed mould diameter of 150 mm, and wet sample mass of 2,800 g

[8][9]. The mix formulation must be developed using a specific mix design method consisting of two phases [10]: in the first phase the optimal water content is defined, while the optimal binder dosage is calculated in the second phase. The optimum water content is defined as the maximum water content that allows less than 0.3% of water loss after the compaction procedure at 100 gyrations. The binder dosage is determined through indirect tensile strength (ITS) test and indirect tensile stiffness modulus (ITSM) test at 25°C on specimens cured for 3 days at 40°C (Table 1). In the case of FDR for minor projects, the mix design of the in-situ cold recycled mixture must be carried out with the support of test pits, including the sampling of an adequate quantity of material from the existing foundation. When the recycling project has a relevant extent, the composition, performance and technical procedures must be defined in a trial section considering at least three areas to be recycled with a length sufficient to ensure the stability of the binder dosage by the respective operating machines (generally greater than 20 m). In the case of CCPR, a trial section can be required to calibrate the construction process for the design mixture produced in the plant. The trial section must have a length sufficient to ensure production and execution stability, as well as a width and thickness in compliance with the project specifications. The design mixture is selected among the mixtures that satisfy the requirements with the lowest stiffness.

For cold recycling practices in Canada, the most used technique is Marshall compaction, but there are some agencies that are moving towards GC compaction. As an example, for mix design, the Quebec province uses a method that allows to find the optimal binder content, while ensuring that the mix is sufficiently insensitive to the effects of moisture. The first steps are to establish the optimum water percentage to achieve a minimum coating of 80% and the highest dry bulk density, based on Marshall compaction. Subsequently, different formulations are prepared according to various bitumen addition contents, the final formulation selected being that which achieves the highest Marshall stability, and the lowest loss of Stability after wet conditioning.

The Brazilian standard states that the mix design process begins with the determination of the so-called "total fluid content", which refers to the sum of the field moisture content of the untreated material, the bituminous emulsion content, and the additional water required for the mixture. This content is calculated using AASHTO Proctor compaction tests at the modified compaction effort (27.1 MJ/m³). The optimum bitumen content is then evaluated through ITS and Marshall stability tests under both dry and wet conditions. The selected bitumen content is the one that simultaneously meets the specified requirements for both tests under both conditions (Table 2). Specimen compaction must be carried out using the GC. This procedure must be performed in a 150 mm diameter mould, with the specimen height equal to 75 ± 5 mm. The compaction pressure should be 600 kPa, the external gyration angle 1.25° , and the number of gyrations should correspond to those required to achieve the maximum dry density determined from the compaction tests.

Alternatively, if GC is not available, the use of Marshall compactor and moulds is allowed, provided that the target dry density is achieved. Although it is not mentioned in the Brazilian standard, the vibratory compactor is also frequently used. This equipment became popular because a comprehensive national standard was not available, and practitioners tended to follow the South African experience [12]. The vibratory hammer, to which a compaction shank is attached, must have a mass of 11.5 kg, a rated power input of 1700 W, an impact rate of 900 to 1700 beats per minute, and an impact energy of 23 J per stroke. Surcharges should also be attached to the hammer to provide a total suspended weight of 33 kg. Specimens with a diameter of 152 mm and a height of 95 mm must be compacted in two equal layers. It is noted that researchers also recommend the use of the vibratory compactor given the limitations in GC availability [13]. The Brazilian standard also requires the construction of a trial section to verify the pavement layer thicknesses and validate the cold recycled mix design.

In Poland the development of the mix design follows this procedure [14][15]: a) selection of the materials and binders and proportions; b) determination of the optimal water content; c) calculation of the additional water; d) compaction of the test specimens; e) curing; f) testing for volumetric and mechanical properties. The optimal water content is determined by means of modified proctor test in 150-mm diameter mould according to the EN 13286-2 standard. The volumetric and mechanical properties of the recycled mixture are assessed using a Marshall compactor under the following conditions: compacting by 75 blows per side in perforated moulds (at least 24 holes of 2 mm diameter evenly distributed on the side of the mould). Samples with a diameter of 101 ± 2 mm and a height of 63.5 ± 3.5 mm should be compacted. The following volumetric and mechanical properties are evaluated: air voids, ITS, and ITSM after 7 and 28 days at 5 °C, and ITS after 28 days. Properties after 28 days of curing determine the acceptability of the mixture. In the case of using cement with other additives the final properties could be determined after a curing time depending on the selected additive. When RA contains tar, the recycled mixtures must be compacted following stricter rules, i.e. air voids content lower than 14 or 12% for low and medium traffic roads, respectively.

In USA, using the FDR technique as an example, the dosage of the stabilizing agent in FDR mixes is typically determined through a mix design conducted by either the agency or the contractor. Various mix design methods are used for FDR materials, depending on project requirements. For cement-stabilized FDR, unconfined compressive strength is the primary property used to establish design thresholds, while ITS is the key criterion for bituminous-stabilized FDR.

Bearing in mind that, in most cases, the property requirements are based on technical specifications from agencies, Table 1 summarises the testing method used for the main phase of the characterization of a cold recycled mixture: optimum water content, compaction, curing, mix design and quality control.

Table 2 shows the typical physical and mechanical requirements for cold recycled mixtures.

Recycling using cement alone has not been considered, as standardized procedures and shared knowledge are already well established worldwide.

Considering at the data presented in Table 1, some observations can be made. Optimum water content, a fundamental parameter in defining the mix design, is investigated in all the countries considered in this review. However, different evaluation approaches are adopted, with varying compaction methods: either static (GC) or impact-based (Marshall and modified Proctor), with a predominance of the latter. Conversely, for specimen preparation, GC is the most commonly used compaction method, although the Marshall compactor is considered an alternative in Brazil and Canada, and is the only permitted method in Poland. A distinctive feature of the Italian technical specifications is the consistency of the compaction method between the optimum water content and mix design phases, with GC employed in both.

As for the curing step, there is significant variability among countries: from single-phase curing at a specific temperature (Italy), to two-step curing under different conditions (Canada, Brazil, and Poland), to curing without a fixed time limit but based on the final volumetric properties of the mixture (USA).

With regard to the different test methods adopted for the mix design phase, laboratory procedures are mainly based on static mechanical tests (ITS and Marshall). Some countries (Italy and Poland) also apply dynamic mechanical tests, such as ITSM. The evaluation of volumetric properties is carried out either in terms of dry density or air voids content. Regarding water susceptibility, only the Italian specifications do not require testing after water conditioning. In the other countries analysed, this property is evaluated through ITS (USA and Poland) or Marshall stability under dry and wet conditions (Canada and Brazil).

Quality control requirements generally follow the mix design characterization tests defined by each country.

About the physical and mechanical requirements presented in Table 2, comparing threshold limits and acceptance values is challenging, given that performance is strongly influenced by compaction and curing methods. Nevertheless, Italy requires the highest strength (ITS) for cold recycled mixtures among the countries considered. It is also worth highlighting the case of Poland, where different requirements are specified for cold recycled mixtures depending on traffic level.

3 Construction process

The construction procedures are quite similar among countries. Cold in-situ recycling with bitumen and cement is commonly carried out using a recycling train, consisting of a volumetric spreader for the cementitious binder, a water tank, a tank for the bituminous binder, a recycling machine, a single-drum vibrating roller, a pneumatic tire roller, and a motorgrader. The existing layer is milled (disaggregated) on-site using one or more passes of a recycling machine or milling machine, down to the design depth.

Table 1. Testing procedures for cold recycling in the selected countries.

| Phase | IT | CA | BR | PL | USA (State of Vermont as a case example) |
|-----------------------|------------------------|---|---|--|--|
| | Foundation and base | Foundation and base | Base | Base | Foundation and base |
| Optimum water content | GC | Marshall | Modified Proctor | Modified Proctor | Modified Proctor |
| Specimen Compaction | GC | GC or Marshall | GC or Marshall | Marshall | GC |
| Curing | 72 h at 40°C, unsealed | 24 h at ambient temperature (in the mold), 24 h at 38° C (unsealed) | Dry: 72 h at 40°C + 12-24 h at 25°C (sealed) Wet: Dry procedure + 24 h immersion at 25°C | Dry: 24 h at 20°C in molds, 28 days at 20°C and 40 -70% RH; Wet: 14 days at 20°C | Free-surface 60°C to constant mass |
| Mix design | Dry density, ITSM, ITS | Marshall stability, Retained stability (dry and wet) | Dry density, ITS at 25°C (dry and wet), Marshall stability at 40°C (dry and wet) | Air voids, ITS, ITSM, ITSr | ITS, ITSr |
| Quality control | Dry density, ITSM, ITS | Voids, Marshall Stability | Dry density, ITS at 25°C, Marshall stability at 40°C, Elastic deflection | Air voids, ITS, ITSM, ITSr | - |

Table 2. Physical and mechanical requirements for recycled mixtures in the selected countries.

| Parameter | IT | | CA | | BR | PL | USA | |
|--|---------|---------|---|--------------|----------------------------------|--|--------|--------|
| | Found. | Base | Found. | Base | Base | Base | Found. | Base |
| Dry density [%] | - | - | - | - | 100 | - | - | - |
| Air voids [%] | - | - | ≤ 15 | - | - | Low traffic: 8 – 18; Medium traffic: 8 - 15 | - | - |
| ITS dry at 25°C after curing [MPa] | ≥ 0.40 | ≥ 0.45 | - | - | ≥ 0.275 | - | ≥ 0.31 | ≥ 0.31 |
| ITS wet at 25°C after curing [MPa] | - | - | - | - | ≥ 0.170 | - | - | - |
| ITS dry at 5°C after 7-day curing [MPa] | - | - | - | - | - | Low traffic: 0,4 - 0,8; Medium traffic: 0,5 - 1,0 | - | - |
| ITS dry at 5°C after 28-day curing [MPa] | - | - | - | - | - | Low traffic: 0.6 - 1.4 Medium traffic: 0.7 - 1.6 | - | - |
| Marshall stability[N] | - | - | 7500 at 22°C; 11 000 if 1.5% cement is added | 7500 at 22°C | 5000 (dry), 300 (wet) at 40°C | - | - | - |
| Retained stability [%] | - | - | 75 | 75 | 70 | - | - | - |
| ITSr [%] | - | - | - | 50 | - | Low traffic: ≥ 70; Medium traffic: ≥ 80 | ≥ 70 | ≥ 70 |
| ITSM at 25°C after curing [GPa] | 3.0-6.0 | 3.0-6.0 | - | - | - | - | - | - |
| ITSM at 5°C after curing [GPa] | - | - | - | - | - | Low traffic: 1.5 - 5.0; Medium traffic: 2.0 - 7.0 | - | - |

In Italy, this operation must be carried out at least one day before the addition of binders and compaction to allow the sampling of the granular mixture for the verification of natural moisture content, bitumen content, and particle size distribution. The in-situ granular mixture must have a

moisture content close ($\pm 2\%$) to the design value established through laboratory studies at least 12 hours before the addition of binders. In Brazil the allowable variation in total fluid content of the cold recycled mixture is -2% to $+1\%$ relative to the optimum value.

When using bituminous emulsion, there is a general consensus in calculate the water content including the water brought in the mixture by the emulsion. After verifying compliance with the design specifications for moisture content, composition, and particle size distribution, the specified amount of cementitious binder is spread over the granular layer. The recycling machine then operates by injecting the design dosage of bituminous binder and mixing it homogeneously to the specified depth.

Compaction is performed immediately using a single drum vibrating roller with a minimum static linear load of 140 kN and a pneumatic tire roller with a minimum weight of 180 kN. In combination with a single-drum vibrating roller and a pneumatic tire roller, the common practice in Brazil recommends the use of a vibratory sheepsfoot rollers with a mass depending on layer thickness, ranging from 120 to 250 kN. The compaction is verified by measuring dry density in comparison with the reference design value as well as conducting deflection survey at specific time intervals.

The surface of the layer is shaped to match the design elevations and slopes using a grader. In some provinces, bituminous emulsion is spread over the surface to ensure proper protection against the traffic from operating vehicles and adverse climatic events.

In Italy, a layer sealing protection is applied 24 hours after the construction by spraying a cationic bituminous emulsion at a rate of 1 kg/m² of residual bitumen, followed by the application of sand. The section is then ready for the construction of the overlying layer [11]. In Brazil bituminous emulsion rate is 1 kg/m², followed by a protective layer consisting of stone dust applied at a rate of 1-2 kg/m². Construction traffic is allowed after 2 hours, and the upper asphalt layer is applied once the moisture content of the recycled layer decreases to 2%. In some cases, particularly on two-lane undivided highways, the recycled layer is initially constructed to match the required final pavement elevation to minimize traffic disruption. As a result, part of this layer is later milled prior to the placement of the asphalt overlay.

As far as the in-plant production concerns, the recycled mixture is generally produced in a twin-shaft counter-rotating mixer or specialized mobile mixers and laid using a paver. The maximum time between mixing and the start of compaction usually must not exceed 60 minutes. During transport from the production plant to the job site, the mixture must be protected to prevent excessive moisture loss. Compaction phase and layer sealing do not differ significantly from what required for in-place production.

In both production processes, detailed operational procedures are often defined in a trial section to verify the acceptability of the cold recycled mixture and to define the types of equipment, the compaction technique, and the number of rollers passes required to achieve the target compaction. In some countries, such as Italy [6] and Brazil, the trial section is mandatory.

The same procedures can be applied using only cement as the binder.

4 Quality control procedures

In Italian motorways, the quality control is daily carried out on production batch of no more than 1000 m². Mechanical characteristics complying with the mix design are verified sampling the loose mixture during production. Density, surface shape and level and layer thickness are verified after the construction [10].

In Canada, whether using CIR or FDR, the performance of the cold recycled material layer is subject to clearly defined quality control requirements. For both CIR and FDR, the contractor is required to monitor the milling depth, material gradation, and dosage of additives and emulsion. For establishing the target compaction level, a reference section is constructed at the beginning of the work, according to the standard for each mix design. Marshall stability at 22°C, retained stability, and compaction density (using a nuclear gauge) are measured on samples taken on site and sent to the laboratory within a maximum of 2 hours. The Marshall stability and post-immersion retained stability of each lot of 7500 m² should be above 7500 N and 70%, respectively. The compaction should be achieved using static, dynamic, or pneumatic rollers and must achieve the required compaction and surface finish of at least 98% of the optimal dry density of the reference strip when measured using a nuclear density gauge. Three samples randomly selected from behind the paver (each 20 kg) are collected from equally sized sections for further specimen preparation. The minimum curing time for FDR is between 48 hours to 3 days. The CIR lots will be rejected if the dry Marshall stability is less than 7000 N and the retained stability is less than 50%. FDR lots will be rejected if the dry Marshall stability is below 500 N, the retained stability is below 50%, and the compaction density is lower than 94% of the maximum dry density of the reference lot.

In Brazil, the thickness of the existing pavement layers and the recycled layer must be verified every 30 m. Quality control of the pavement mixtures should be carried out through tests for particle size distribution, moisture content, and RA bitumen content, performed every 250 m. Control of the cold recycled mixture must include tests for particle size distribution, moisture content, residual bitumen content, maximum dry density (AASHTO modified effort), and in situ dry density, also at intervals of 250 m. Additionally, samples must be compacted for dry ITS and dry Marshall stability tests every 8 hours. Finally, the elastic deflections of the layer must be measured, preferably using the falling weight deflectometer, 14 days after construction.

In Poland, regardless of the used technique the requirements for the cold recycled material mixture course are the same. The constructed course requirements are geometry, compaction and bearing capacity. In the case of geometry requirements, the tolerances for design values are as follows: thickness $\pm 10\%$; width of the course $-5\text{ cm} / +10\text{ cm}$; evenness 15 mm or 12 mm on 4 m base for low and medium traffic respectively. The compaction ratio of the compacted course should be not less than 98%. Air voids in compacted course should be no higher than 15% and 12% respectively for low and medium traffic. Current experiences with this type of base course showed that those values are difficult to obtain,

and in the next revision of the requirements, the values of maximum air voids should be considered higher. Bearing capacity of the compacted course is determined by the means of static plate load testing. Measuring deflections using a Portable Impulse Plate Load Test Device is also acceptable. The minimum bearing capacity is 100 MPa and 130 MPa at 7 days after construction, and 140 MPa and 180 MPa at 28 days after construction, for low- and medium-traffic roads, respectively. The biggest problems are observed for air voids content and compaction ratio, due to coarse material and binding of the recycled materials. In some cases, the aforementioned tests are not performed, due to problems with obtaining reliable specimens (cores) for testing. In this case only the compaction ratio is tested directly after course compaction. Requirements for control of the constructed cold recycled material layer are adjusted on selected projects to local conditions. For example, the curing duration of specimens is adjusted when cement is used or the test method is changed due to problems with fast preparation of specimens and the possibility of storing them in appropriate conditions.

In the United States, the NCHRP 9-60 study [16] offered practical guidance for quality control and acceptance of cold recycling construction practices. The study introduced the use of shear and raveling tests to assess the appropriate timing for reopening a recycled pavement layer to traffic or applying a surface course. Specifically, the long-pin shear test, which evaluates both the number of blows and applied torque, was recommended to determine the readiness for surfacing, whereas the short-pin raveling test was suggested for assessing when traffic loading could commence. Statistical analyses were used to establish threshold criteria for both tests, with the guidance that these procedures are applicable only for recycled layers with a minimum thickness of 76 mm.

5 Conclusions

As previously mentioned in this paper, cold recycling cannot be regarded as a single, standardized technique, and given the lack of globally accepted laboratory and field procedures, universities, research centres, and road administration agencies have developed their own methodologies. Defining universally valid procedures is challenging due to the numerous variables involved in the technology (e.g., RAP quality and availability, type and dosage of cement, type and dosage of bituminous binder, etc.).

Based on the information presented in this paper, the following conclusions can be drawn:

- There is consensus on the importance of optimum water content in mix design, regardless of the specific cold recycling technology adopted. However, different evaluation approaches are applied in the countries investigated, with considerable variation in compaction equipment;
- In most of the countries analysed, the specimen preparation method differs between the optimum water content phase and the mechanical characterization phase. The consistency of the mix design procedure should be thoroughly analysed and improved.
- For laboratory sample preparation, the gyratory compactor appears to be the most widely adopted method, although the Marshall compactor is in use;
- Curing procedures vary considerably among countries, involving either single- or multi-phase processes under different temperature and sealing conditions;
- Laboratory characterization is mainly based on static mechanical tests, although some countries have also introduced dynamic mechanical tests. A direct comparison of mechanical requirements is difficult, since performance is strongly influenced by the adopted compaction and curing procedures;
- Laboratory procedures for material characterization do not change for foundation or base courses, whereas requirements change, moving towards higher performance and more selective testing for base courses;
- The construction process follows broadly similar practices across the countries analysed. The application of a protective coating on the surface of the cold recycled layer (e.g., bitumen emulsion) is a common practice;
- Considering the multiple variables of cold recycling technology, implementing trial sections is good practice for validating the laboratory-developed mix design and ensuring material homogeneity and performance in the field.

Future perspectives should focus on expanding field experience with lime and modified emulsions, which are not yet widely used but show considerable promise.

Authorship statement (CRediT)

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Conflict of interest

The authors declare no conflict of interest.

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References

- [1] Tebaldi G., Dave E. V., Marsac P., Muraya P., Hugener M., Pasetto M., Graziani A., Grilli A., Bocci M., Marradi A., Wendling L., Gaudefroy V., Jenkins K., Loizos A., Canestrari F., "Synthesis of standards and procedures for specimen preparation and in-field evaluation of cold-recycled asphalt mixtures", *International Journal Road Materials and Pavement Design*, Volume 15, Issue 2, pp. 272-299.
<https://doi.org/10.1080/14680629.2013.866707>
- [2] Bocci M., Grilli A., Cardone F., Ferrotti G., "Full Depth Reclamation for the Rehabilitation of Local Roads: a Case Study", *International Journal of Pavement Engineering*, Volume 15, Issue 3, pp. 191-201, 2014.
<https://doi.org/10.1080/10298436.2012.657196>
- [3] Ferrotti G., Grilli A., Mignini C. and Graziani A., "Comparing the Field and Laboratory Curing Behaviour of Cold Recycled Asphalt Mixtures for Binder Courses", *Materials by MDPI*, ISSN 1996-1944; CODEN: MATEG9, Materials 2020, Special Issue Characterization of Innovative Asphalt Materials for Use in Pavement Design and Analysis 13(21), 4697.
<https://doi.org/10.3390/ma13214697>
- [4] Carter A., Perraton D., Raschia S., Grilli A., Graziani A., Pasquini E., Kara De Maeijer P., Lo Presti D., Pasetto M., Tebaldi G., Dave E., "State-of-the-Art of the RILEM Technical Committee 264-RAP, Recycling Asphalt Pavement", Chapter 1 "Impact of the Compaction and Curing on the Properties of Cement-Bitumen Treated Materials (CBTM)", Springer Cham, ISBN 978-3-031-94230-3, 2025.
- [5] Cardone F., Graziani A., Grilli A., Bocci M., "Curing and temperature sensitivity of cement-bitumen treated materials", *International Journal of Pavement Engineering*, Vol. 16, No. 10, 868-880.
<https://doi.org/10.1080/10298436.2014.966710>
- [6] Graziani A., Grilli A., Mignini C., Balzi A., "Assessing the Field Curing Behavior of Cold Recycled Asphalt Mixtures," *Advances in Materials Science and Engineering*, vol. 2022, Article ID 4157090, 13 pages, 2022.
<https://doi.org/10.1155/2022/4157090>
- [7] 308-PAR: Performance-based Asphalt Recycling, (n.d.). <https://www.rilem.net/groupe/308-par-performance-based-asphalt-recycling-441> (accessed February 18, 2025).
- [8] Grilli A., Graziani A., Bocci M., "Compactability and Thermal Sensitivity of Cement-Bitumen Treated Materials", *International Journal of Road Materials and Pavement Design*, Vol. 13, Issue 4, pp. 599-617.
<https://doi.org/10.1080/14680629.2012.742624>
- [9] Grilli A., Graziani A., Bocci E., Bocci M. "Volumetric properties and influence of water content on compactability of recycled mixtures", *Materials and Structures*, ISSN 1359-5997, Volume 49, Number 10, DOI 10.1617/s11527-016-0792-x, 2016.
<https://doi.org/10.1617/s11527-016-0792-x>
- [10] Graziani A., "The Italian Experience on Cold Recycling: from Research to Construction Specifications for Motorways", 1st International Workshop on Asphalt Recycling Technologies, 9-10 September, 2024 RWTH Aachen, Germany
- [11] Bocci M., Canestrari F., Grilli A., Pasquini E., Lioi D., "Recycling Techniques and Environmental Issues relating to the Widening of a High Traffic Volume Italian Motorway", *International Journal of Pavement Research and Technology*, Chinese Society of Pavement Engineering, ISSN: 1996-6814, Vol. 3, Issue 4, pp. 171-177, 2010.
- [12] Asphalt Academy, Technical Guideline TG2: Bitumen Stabilised Materials: A Guideline for the Design and Construction of Bitumen Emulsion and Foamed Bitumen Stabilised Materials, Asphalt Academy, Pretoria, South Africa, 3rd edition, 2020.
- [13] João Paulo Costa Meneses, Kamilla Vasconcelos, Liedl L. B. Bernucci & Elie Hajj (2021) Compaction methods of cold recycled asphalt mixtures and their effects on pavement analysis, *Road Materials and Pavement Design*, 22:sup1, S154-S179,
<https://doi.org/10.1080/14680629.2021.1908405>
- [14] Dożycki B., Jaskała P. "Review and evaluation of cold recycling with bitumen emulsion and cement for rehabilitation of old pavements", *Journal of Traffic and Transportation Engineering*, ISSN 2095-7564, Volume 6, Issue 4, pp. 311-323.
<https://doi.org/10.1016/j.jtte.2019.02.002>
- [15] Dożycki, B., Jaczewski, M., Szydłowski, C., Bańkowski, W., & Gajewski, M. D. "Analysis of selected mechanical properties of mineral-cement-emulsion mixtures (MCE)", *Roads and Bridges - Drogi i Mosty*, ISSN 1643-1618 Volume 22, Issue 1, pp. 41-61,
<https://doi.org/10.7409/rabdim.023.003>
- [16] Diefenderfer, B. K., Boz, I., Habbouche, J., Jones, D., Hand, A. J., Bowers, B. F., & Flintsch, G. (2021). Proposed AASHTO practice and tests for process control and product acceptance of asphalt-treated cold recycled pavements (No. Project 09-62).
<https://doi.org/10.17226/25971>