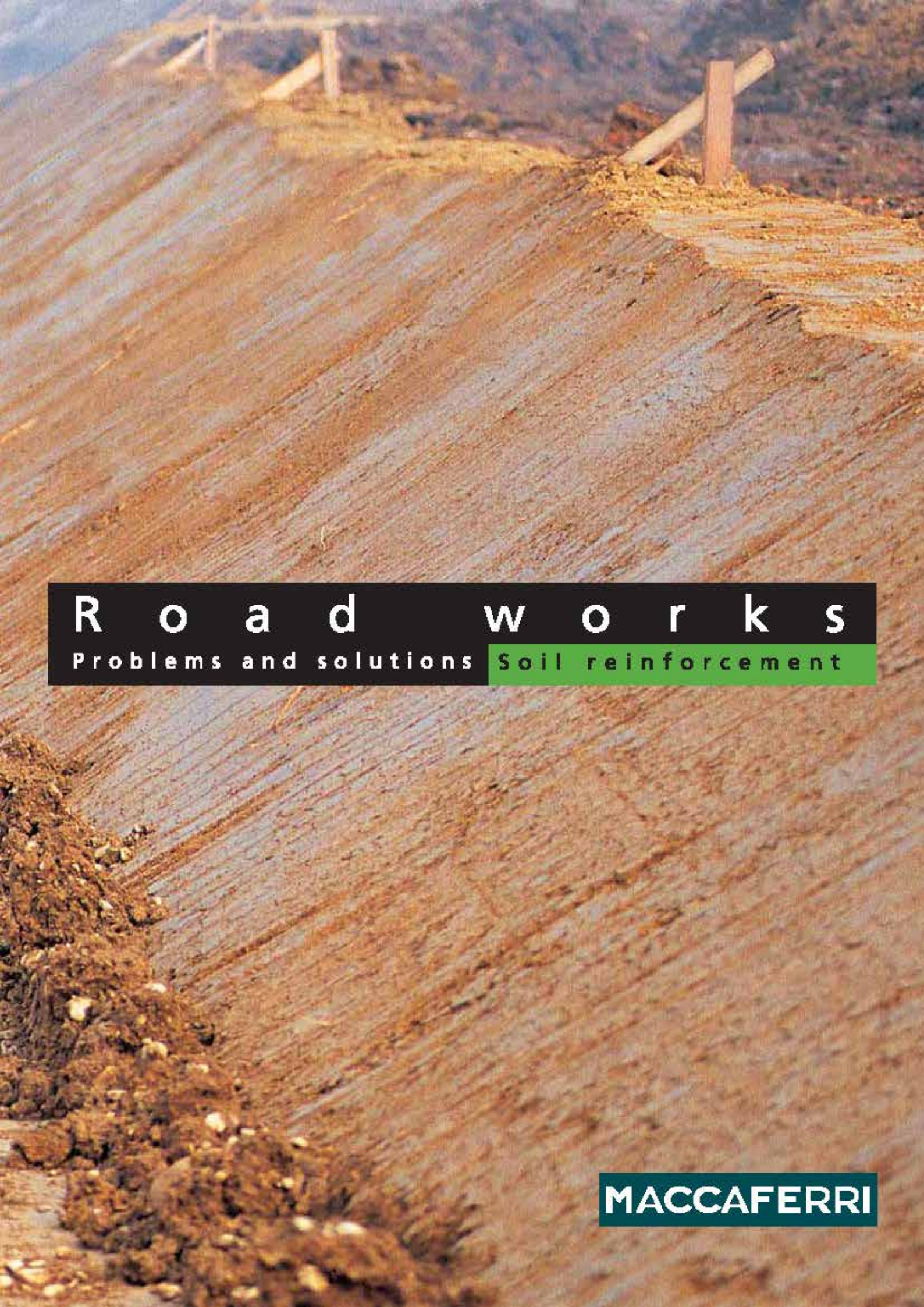


Road works

Problems and solutions

Soil reinforcement

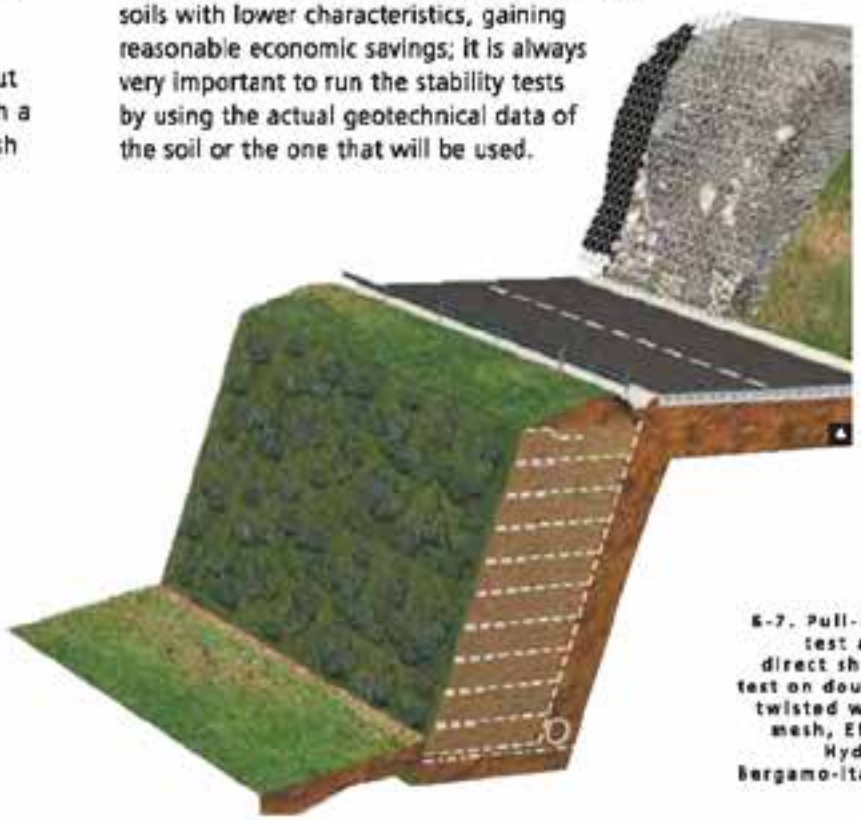
MACCAFERRI

Maccaferri solutions for soil reinforcement works

Thanks to the experience and the technological development of new materials, the soil reinforced structure can be considered as the traditional solution for reinforcement works.
Therefore, the numerous applications of these structures demonstrate the validity and the convenience of these systems: road reinforcement works, landfill embankments, noise barriers, river and rockfall barrier embankments.
Maccaferri started its experience in Reinforced Soil using double twisted wire mesh with a structure built in Sabah (Malaysia) in 1979; Since then, through continuous internal technical research and with the cooperation of the most prestigious Research Institutes, Maccaferri has now developed a knowledge strong enough to offer the market competitive technical solutions able to guarantee durability in time and in the most difficult situations.
The Terramesh® system developed by Maccaferri is formed by pre-assembled units which reduce installation time and form the front face and reinforcement without any discontinuity (without joints) in order to create a complete system with a wide differentiation both of front face wire mesh reinforcements, and geogrids.

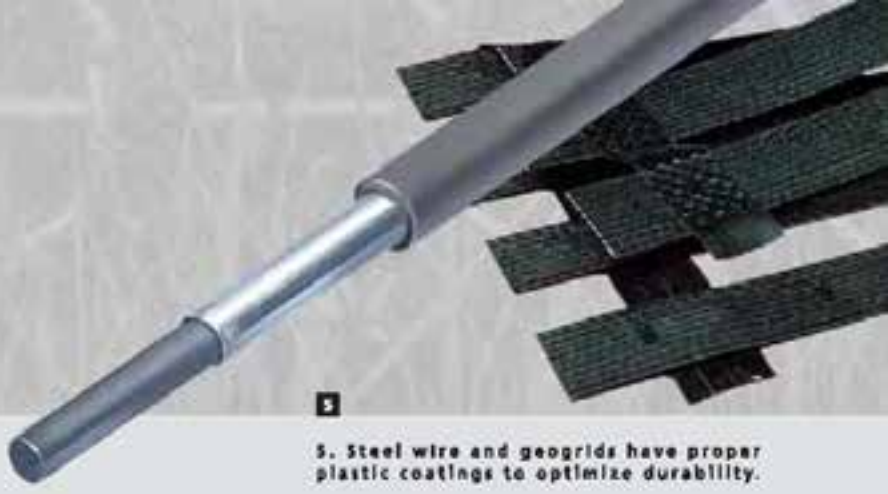
Soil reinforcement

Soil reinforcement works are structures for the containment or stabilization of slopes and embankments, through traction-resistant reinforcement elements that change the mass inner features where they are inserted.
In the case of containment structures, the Soil Reinforcement becomes a technical/structural alternative to reinforced concrete or crib walls.
As a matter of fact, not only does it have a lower environmental impact but it is also economically competitive. The great flexibility of a Soil Reinforcement structure allows its use even on week soils, as it is able to adapt to base settlements with moderate deformations. This type of structure has a great inner seismic resistance.
In case of slope or embankment stabilization it is possible to minimize the use of granular soil with high geotechnical characteristics by exploiting soils with lower characteristics, gaining reasonable economic savings; it is always very important to run the stability tests by using the actual geotechnical data of the soil or the one that will be used.



5-7. Pull-out test and direct shear test on double twisted wire mesh, ENEL Hydro, Bergamo-Italy.

1-2. One of the first examples of reinforced soil walls using gabions with "Soil Reinforced" system along the road from Sinsuran to Kota Kinabalu, Malaysia-Sabah.



5. Steel wire and geogrids have proper plastic coatings to optimize durability.

Tests

To provide a correct design the analysis of the materials' behavior fitted in the soil has always been a specific object of study of Maccaferri. Maccaferri went into details in the study of the behavior of double twisted wire mesh in compacted granular and cohesive soils (Australian Defence Force Academy – Camberra, Federal Highway Administration – USA, ISMES – Bergamo, Italy).

The study of the deformations of different stiffness reinforcement (ISMES – Bergamo, Italy, "Bathurst" – Canada) has allowed the possibility to develop the combination of double twisted wire mesh products with high resistance geogrids, thus increasing the range of possible solutions. Moreover, these tests have given Maccaferri the opportunity to obtain appropriate criteria to be used during the design phase of the work. In addition, the tests have helped to create a new Software (Macstars 2000) which uses the most advanced geotechnical techniques on soil's behavior.

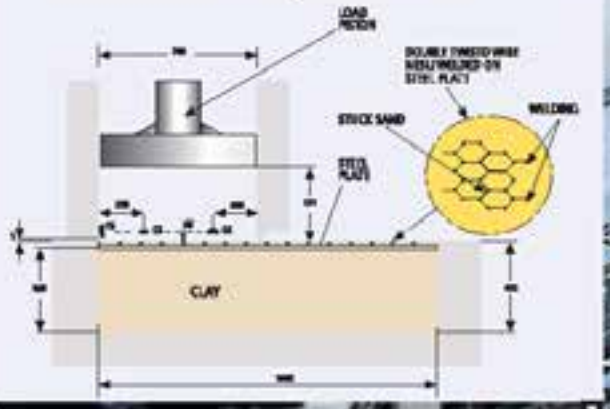
Durability

Durability, resistance, and safety are some of the fundamental elements on which Maccaferri engineers have concentrated their attention and resources. Durability depends not only on the criteria and the models used during the design phase, but also on the technical characteristics of the materials used for the work.

The selection of materials with appropriate protection revetments and the utilization of correct safety parameters in the design activity, make Maccaferri a leader in the quality standards required by the most demanding Institutions.

The Terramesh® system is formed by double twisted wire mesh units made of steel wire protected with a eutectic alloy of zinc and alluminium and rare earths plus an additional plastic coating which can even be linked to polyester geogrids, polyolefin coated, to provide optimum durability up to 120 years as required by the most strict international requirements.

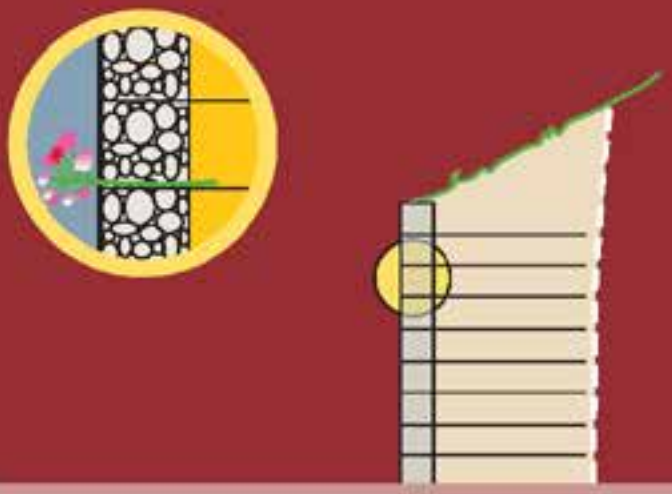
Direct smeare box, testing interface soil/mesh



8. Research into the behavior of double twist wire mesh as reinforcement Camberra University, New South Wales-Australia.

Front faces: criteria for the solution choice

- Aesthetic fitting in the surrounding environment.
- Regreening possibility thus meaning an adequate filter, presence of a vegetal soil external layer and in cooperation with experts, execution of hydroseeding and a possible fitting of plant cuttings. In dry climate or where work maintenance is not planned, it is advisable to use stony front faces.
- Structural continuity with the reinforcement.
- The industrial production of Terramesh® elements, that ensure the choice of materials and their quality assembly.
- Availability of support technical material and technical assistance at the job-site to ensure a good result in the placement process.

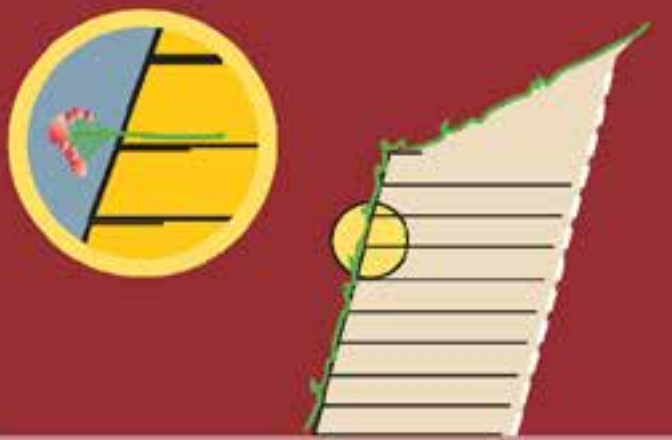


TERRAMESH® WITH A VERTICAL FACE

11

TERRAMESH® WITH A BATTERED FACE

12



GREEN TERRAMESH®

13

11. Retaining wall structure in Terramesh® S 23 m high in mine industry, Sumbawa-Indonesia.

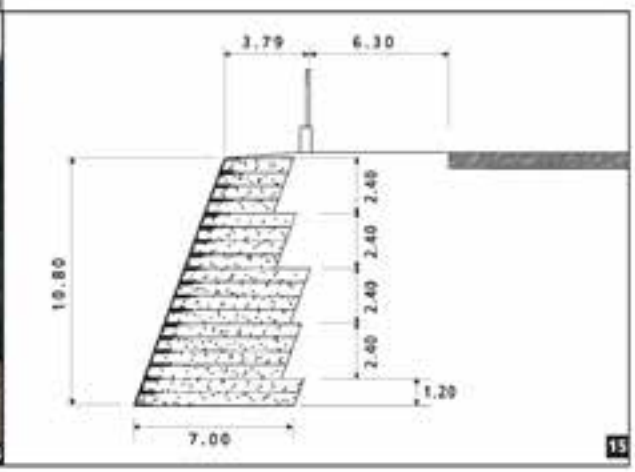
12. Retaining wall structure along a road in Terramesh® S, Souther Highlands, Papua New Guinea.

13. Front face of Green Terramesh®, Casalecchio di Reno (BO)-Italy.

The reinforcement: solutions

Terramesh® system


14



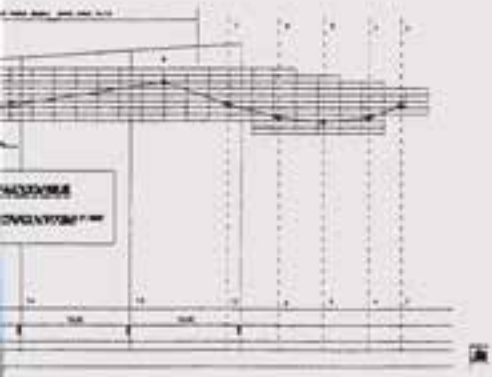
15

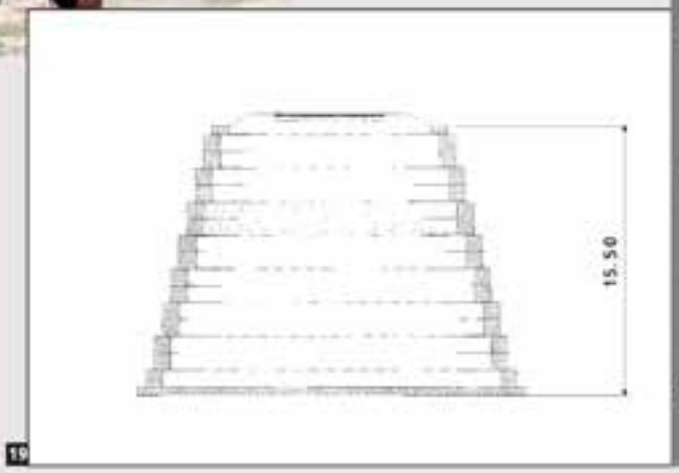
16

14-15-16-17. Retaining work along race track at Imola carried out by using soil type reinforced green Terramesh®, Imola-Italy.


17

18-19. Road embankment in Terramesh® S and geogrids, Aliano (MT)-Italy.





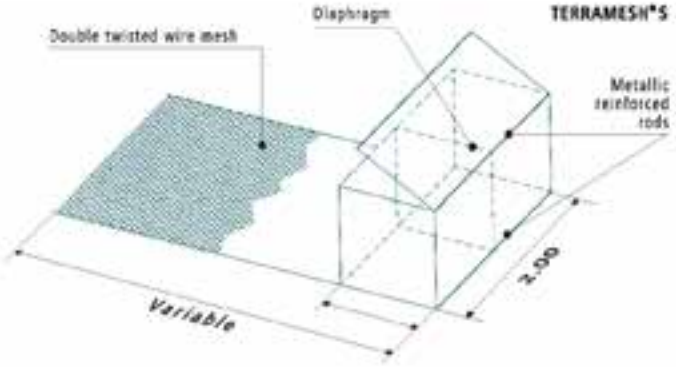
20-21. Slope stabilization in geogrids, Passignano (PG)-Italy.



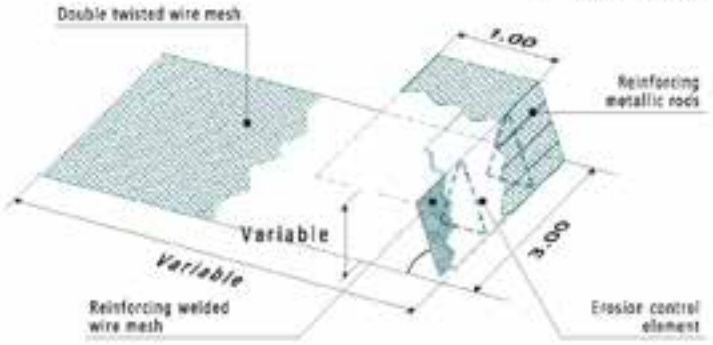

The Terramesh® system

Close cooperation with construction companies has allowed Maccaferri to offer products created to reduce the placement cost and problems on the construction site.
Installation of the Terramesh® system can be easily and rapidly executed by unskilled staff after proper training.
Compliance with the installation instructions given by Maccaferri is fundamental to obtain a solid, lasting and cost-effective structure.
In addition, they ensure safety on the job site.
Compaction and preparation of soil is carried out with traditional equipment in accordance with all relevant local specifications for road construction.
The structural embankment should be of select good quality granular fill, with a high draining capacity and high angle of internal friction. Particularly its characteristics must remain unaltered in time. If this is not possible, it is necessary to make sure that the design has taken into account the characteristics of the soil used during placement.
The results of the tests have demonstrated that a grading, varying from 0,02mm up to 6 mm (100% passing) is an optimum scale of values for the embankment. You can also use greater gradations in case a partial safety factor is inserted in the reinforcement to prevent possible coatings damage.
In the case of green face, in order to obtain the maximum effectiveness in the greening process, it is necessary to prepare a small layer of vegetal soil in the area immediately lying behind the external face.
An appropriate hydroseeding and fitting of plant cuttings will have to be considered to ensure the greening process taking into account the local climatic situation, the exposure, the geometry of the project, and the floristic-vegetation characteristics of the area.

TERRAMESH®S



GREEN TERRAMESH®



Single factory-made unit, folded and ready to place in position.

Single factory-made unit, folded and ready to place in position, including the revegetation matrix, an additional welded mesh panel, triangular reinforcing steel brackets.

Unit in position, opened out along the folded corner.

Unit in position, opened out along the folded corner to the required slope.

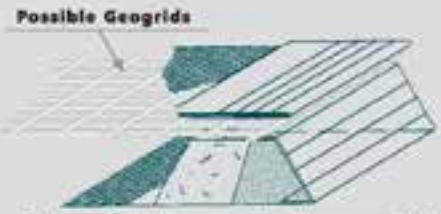
Partition panels (diaphragms) attached by wiring on a edges.

Opening and pivoting of the triangular supporting brackets.

Gabion portion filled with stone, and lid wired down. Geotextile positioned and backfilling commenced.

Backfilling up to desired level.

Placing next unit on top, possible layer of Geogrids.



Folding of the face upper side. Placement of the next unit and attaching by stainless steel rings to the unit below. Possible layer of Geogrids.

Calculation: the future built on

The design choices are the results of quantitative analysis and not only qualitative or subjective ones. This is the reason why our company has promoted laboratory, on-site and bibliographical researches, which furthered a series of specific software like MACSTARS for reinforced soil structures. These instruments were conceived as evolving tools i.e. ductile instruments that can be updated and improved continuously. This "deeds, not words" philosophy supports a presence and a willingness which have characterized Maccaferri as a solution provider, (not only a products one), since last century up to the beginning of the third millennium.

MACSTARS 2000

Maccaferri Stability Analysis of Reinforced soils

The MACSTARS program was developed to check the stability of reinforced soils, e.g. structures which ensure slope stability by using reinforcement units able to absorb the tensile strength. Furthermore this program allows to conduct the stability checks in absence of reinforcement, using the Limit Equilibrium Method.

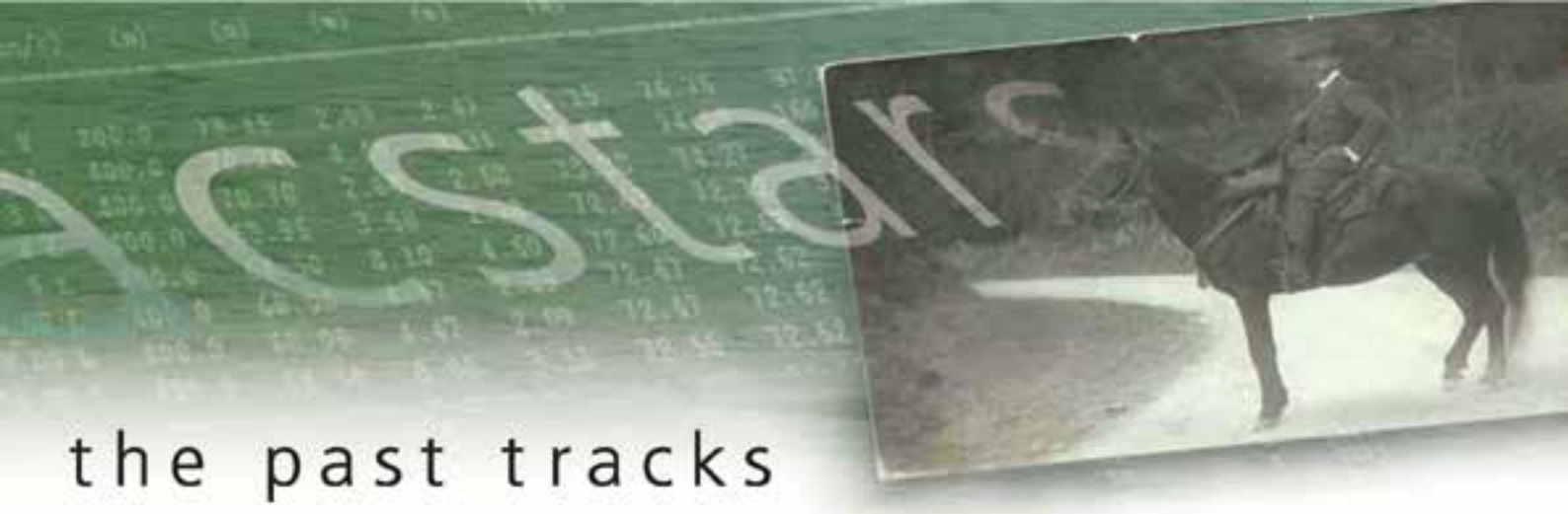
The MACSTARS program distinguishes itself for its flexibility, both in elaborating specific and complex solutions, and for the possibility to verify all the design aspects considering the various materials of reinforcement, the different national standards, all the possible external requirements, the various geometries, the different soil typologies and the possible hydraulic stresses.

The test are carried out referring to the real geometry of the reinforced soil structures.

In the case of complex slopes (e.g. due to the presence of several isolated works); it is possible to represent the whole-slope, taking into account the mutual interaction of the works.

Besides its flexibility, the major innovative aspect exists in the opportunity to use deformation methods (with forced or incremental displacement) that allows a careful analysis of the reinforcement stresses and a more realistic verification of stability. The displacement method differs from the traditional one only for the reinforcements' simulation period. In the rigid method, every force is simulated by another force equal to the minimum value between tensile strength and pull-out load.

In the displacement method the reinforcement is simulated through a force which depends on the deformation exerted on the reinforcement and on its elasticity characteristics.

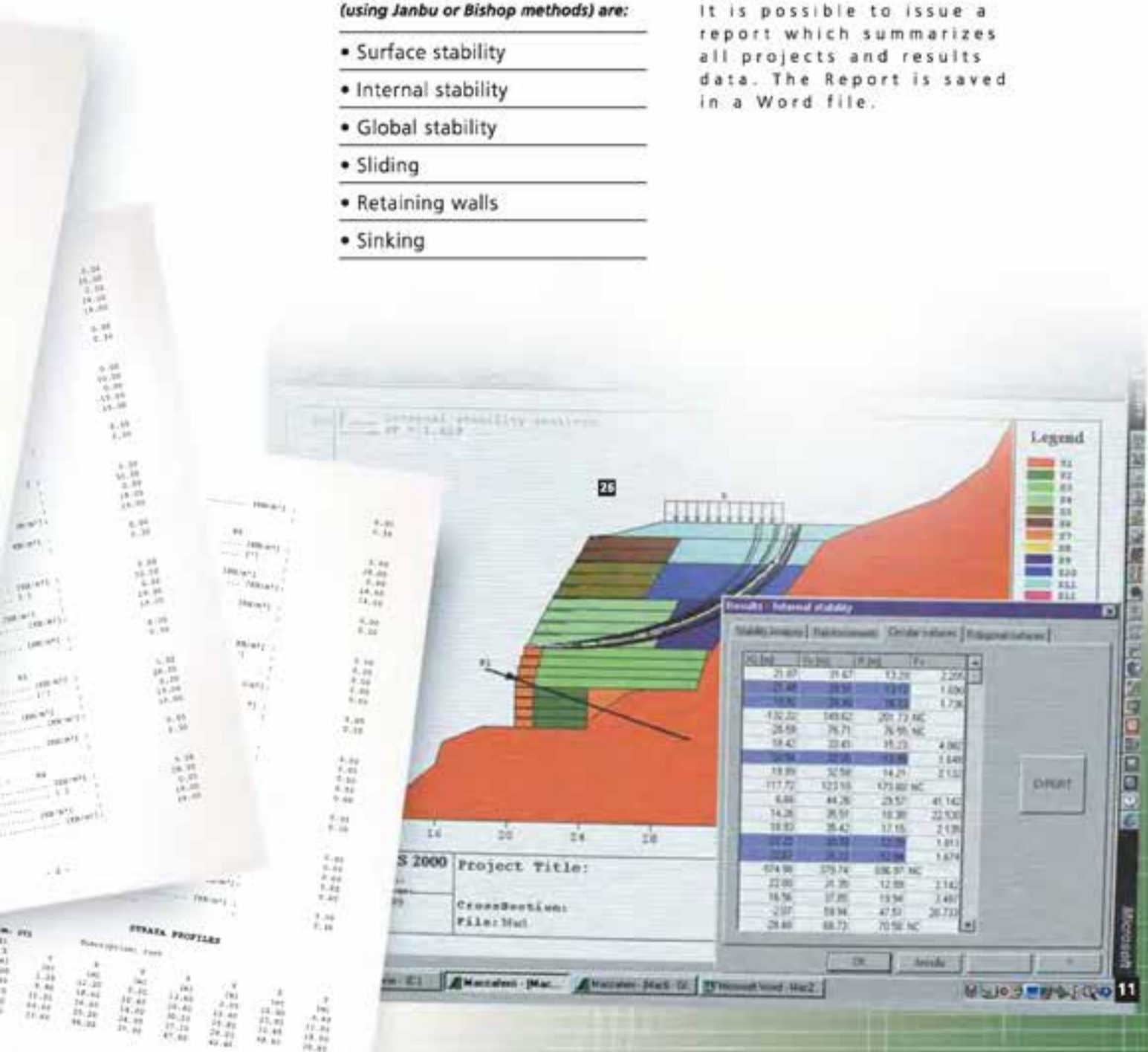


the past tracks

Possible checks
(using Janbu or Bishop methods) are:

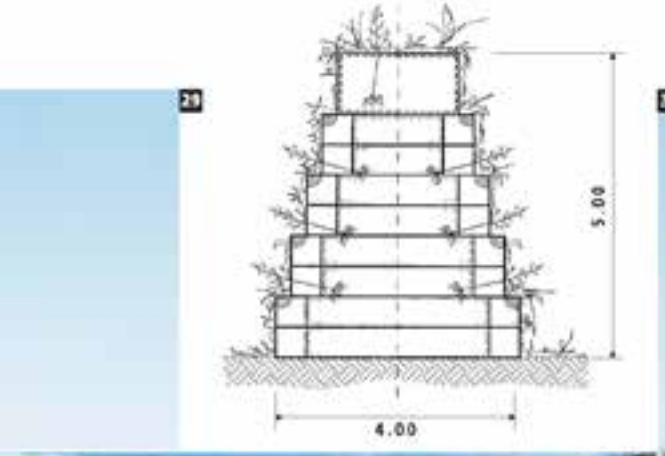
- Surface stability
- Internal stability
- Global stability
- Sliding
- Retaining walls
- Sinking

Report
It is possible to issue a report which summarizes all projects and results data. The Report is saved in a Word file.



27-28. Green Terramesh®sound barrier in urban area, Bologna-Italy.

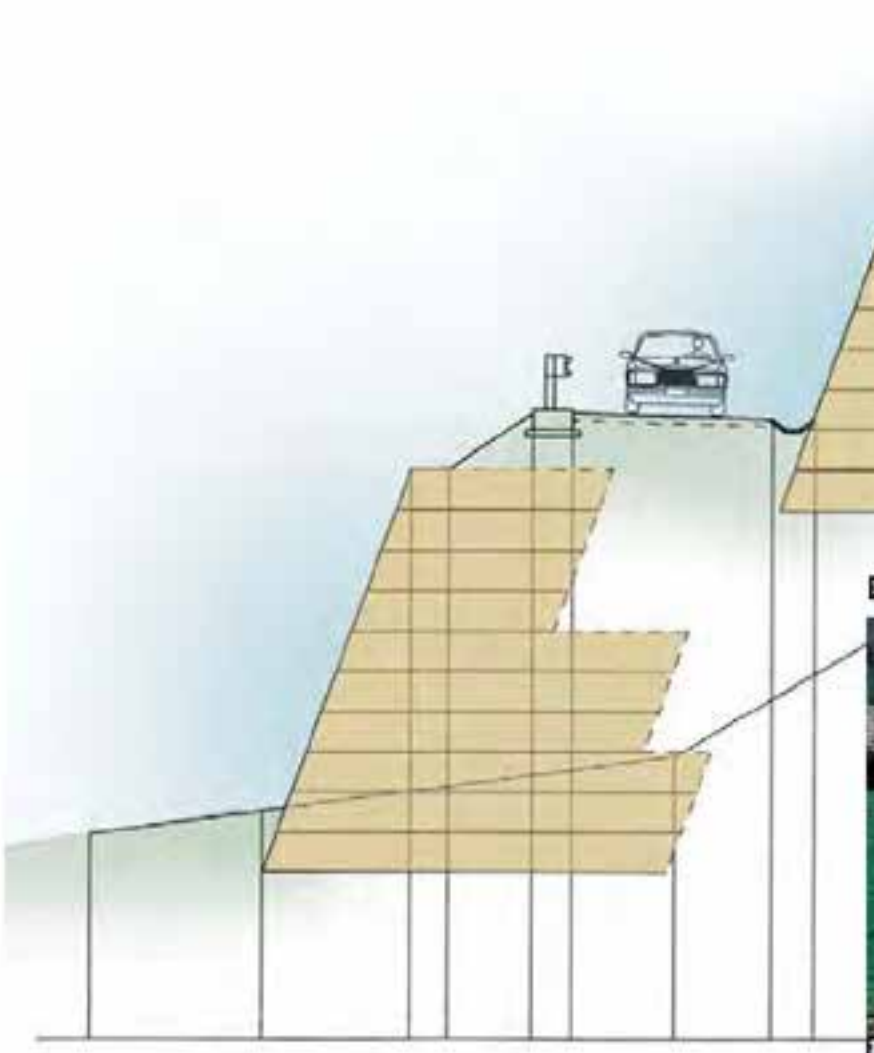
Our experience



29-30. Terramesh® S sound barrier to protect tourist village from Roma – Pisa railway, S.Vincenzo-Italy.

31, 32. Retaining structure in Green Terramesh®
to extend industrial building, Arcevia (AN)-Italy.

33-34. Green Terramesh® retaining
structure to extend toll barrier,
Villesse (GO)-Italy.



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35-36-37. Road restructuring using Green Terramesh®, Valle d'Ogna (BG)-Italy.

38-39. Green Terramesh® retaining wall, Civitanova Marche (MC)-Italy.

38

39

40-41. Slope stabilization with geogrids, Tapei-Taiwan.

42. Road embankment and culvert protection with Terramesh® S and gabions, Picerno/Baragiano (PZ)-Italy.

43-44. Green Terramesh® Water retaining wall, Masseria Crisci (MT)-Italy.

45-46. Retaining wall and hydraulic works with Green Terramesh® Water, Ugovizza (UD)-Italy.

47-48. Road embankment using geogrids and Green Terramesh® mixed structure, Villamassargia (CA)-Italy.

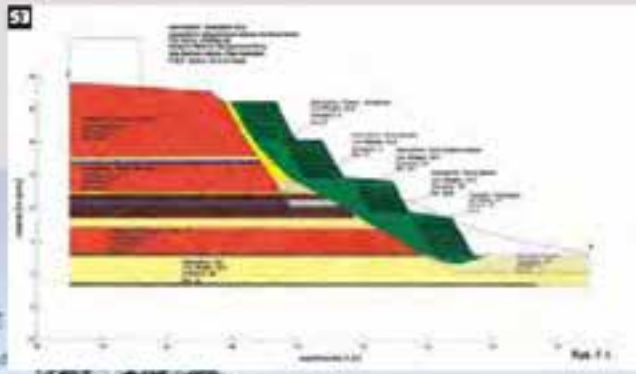
54. Slope stabilization, Jastrzebiej Gorze-Poland.

49. Green Terramesh® retaining structure, Bologna-Italy.

50. Retaining wall for new parking area with Green Terramesh ®, Ariccia (RM)-Italy.

51. Retaining structure with Terramesh® S for new residential area, Christchurch, -New Zealand.

52. Retaining wall structure with Terramesh® S in mine industry , Sumbawa-Indonesia.



55-56. Green Terramesh® retaining structure in Fori Imperiali archeological area, Roma-Italy.

60-61-62. River bank protection for environmental rearrangement and the construction of a cycle footstep using Terramesh, Casalecchio di Reno (BO)-Italy.

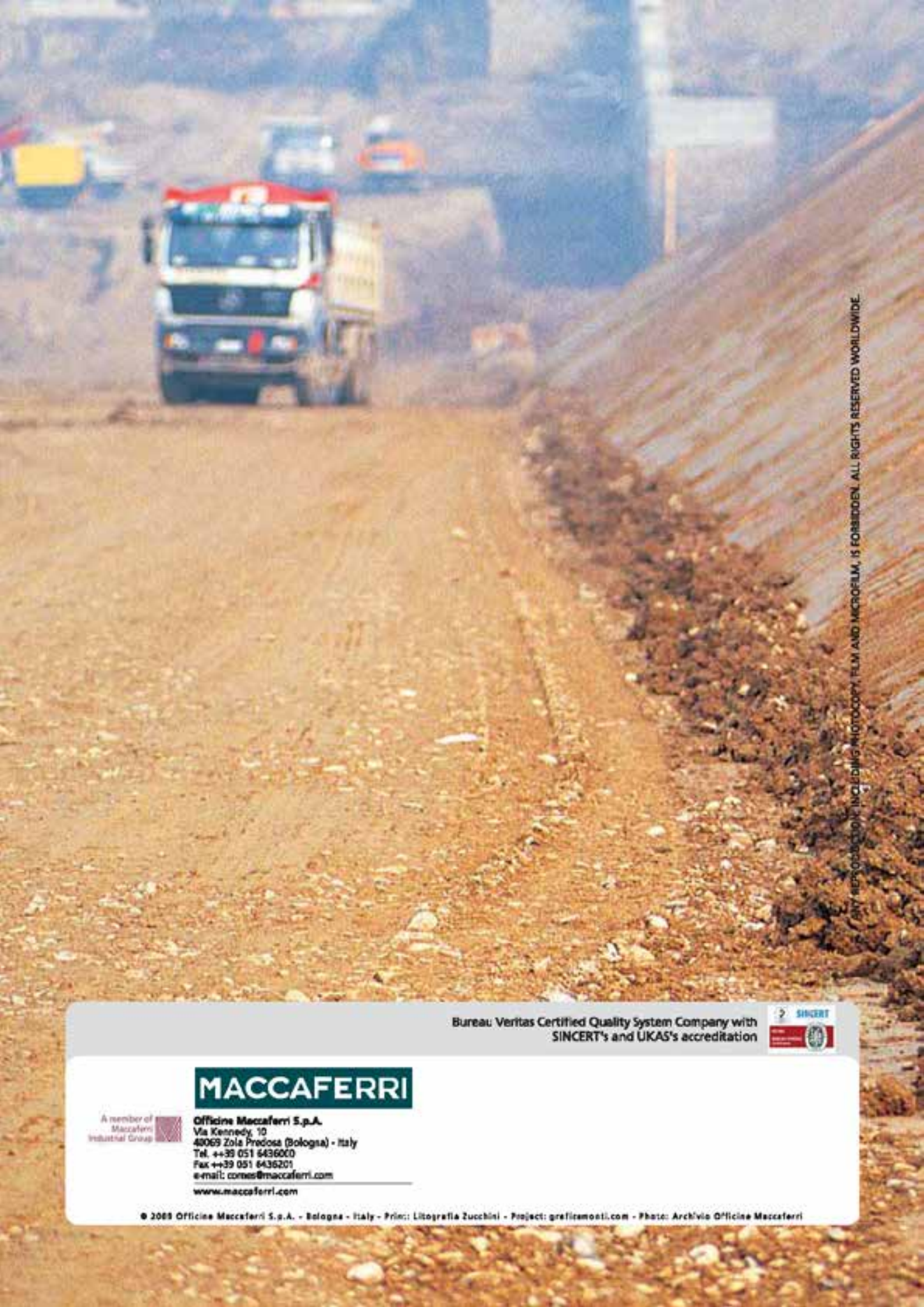
57. Terramesh® S retaining wall, Yaug Doug Express Way-South Korea.

58. Hydraulic protection with Terramesh® S and gabions, Vella river, Sulmona (AQ)-Italy.

59. Retaining structure in Sidney 2009 Olympic Site-Australia.

63. Geogrids retaining structure for enlargement of a road, Arcola (SP)-Italy.

64. River bank protection with Green Terramesh® Water, Cogne (AO)-Italy.



Bureau Veritas Certified Quality System Company with SINCERT's and UKAS's accreditation

MACCAFERRI

A member of Maccaferri Industrial Group

Officine Maccaferri S.p.A.
Via Kennedy, 10
40069 Zola Predosa (Bologna) - Italy
Tel. ++39 051 6436000
Fax ++39 051 6436201
e-mail: comes@maccaferri.com
www.maccaferri.com

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