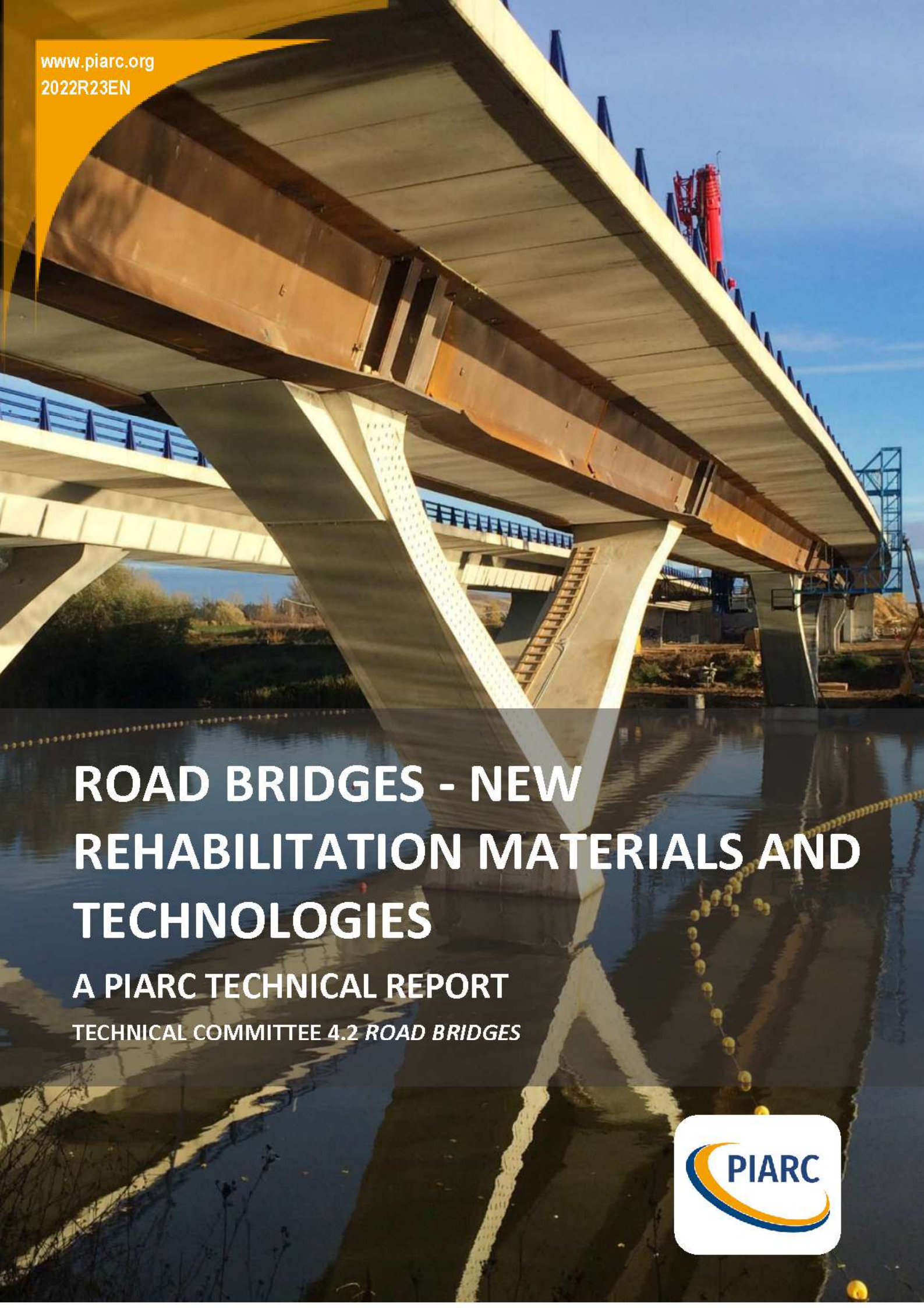
www.piarc.org
2022R23EN



ROAD BRIDGES - NEW REHABILITATION MATERIALS AND TECHNOLOGIES

A PIARC TECHNICAL REPORT

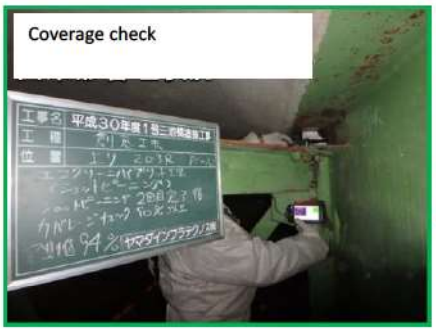
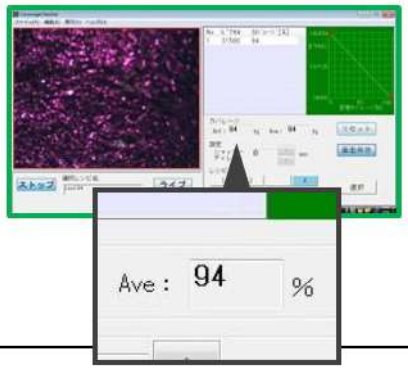
TECHNICAL COMMITTEE 4.2 *ROAD BRIDGES*

PIARC

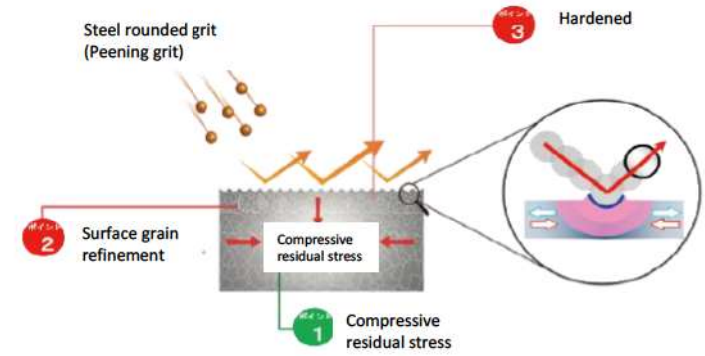
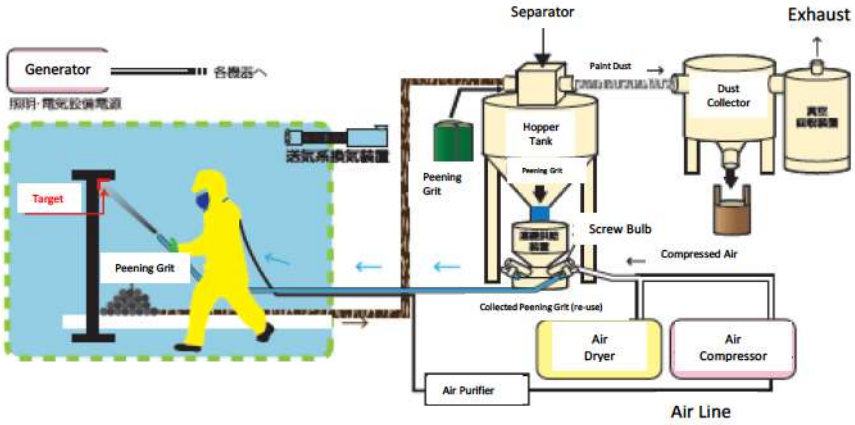
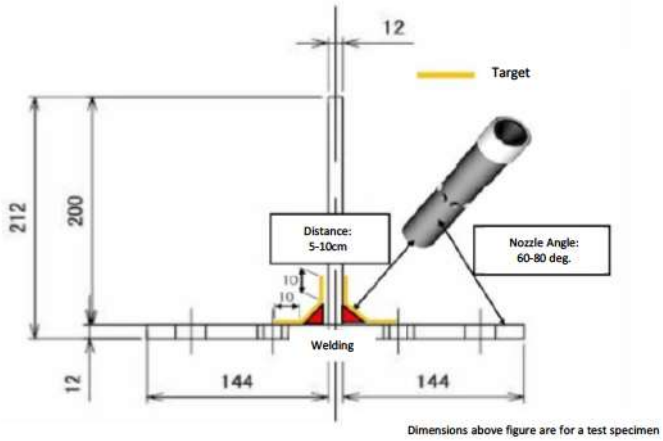
CONTENTS

15.29. CASE 29: FATIGUE CRACKS IN A NON COMPOSITE STEEL GIRDER BRIDGE (JAPAN)

Case: *Fatigue cracks in a non composite steel girder bridge (Japan)*	
1) Brief description of the bridge (type, material, construction time,...	Provide a short description of the bridge including bridge type, material (steel, reinforced concrete, prestressed concrete, timber, bricks,...), construction time, span lengths,...
Answer	Kaminagakubo Br. (Inbound & Outbound) • Bridge type: 3+2+3 span continuous non-composite steel plate girder bridge • Bridge length: 300m • Main span: 37.5m • Completion year: 1969
Picture of the bridge	
2a) Brief description of the need of rehabilitation	Describe why it is necessary to rehabilitate the bridge: degradation (which type), increasing service level (load capacity for example),...
Answer	Because of aging and heavy traffic, it was decided to take countermeasures against fatigue crack from the point of view of preventive maitenance.

Case: *Fatigue cracks in a non composite steel girder bridge (Japan)*	
Picture	      

Case: *Fatigue cracks in a non composite steel girder bridge (Japan)*	
2b) Is this need of rehabilitation related to the effect of climate change	Is the need of rehabilitation related to climate change effects? For example: • Due to increasing flooding risk you may need to improve scouring protection of piers. • Due to increasing heavy rains you decide to increase drainage capacity. • Due to increasing temperature you use a new asphalt pavement with higher heat-resistance • ... If yes, explain.
Answer	No
3a) Describe your New rehabilitation materials and/or technologies.	Make a short explanation of the rehabilitation's materials and/or technologies that were applied. Give the year of completion
Answer	Shot peening is a technique to increase in fatigue and stress corrosion cracking resistance. It is a steel surface treatment of steel grit & shot to provide its surface with minor plastic deformation and beneficial compressive residual stress. It prevents cracks from progressing by making its surface grain refinement. It also prevents its surface from being scratched by making it hardened. The technique has been applied only at a factory, not at a bridge site, because of necessity of a large-scale countermeasure against antiscattering as well as difficulty of collection & reutilization of steel grits at a bridge site. Following measures, however, enabled its application at an existing bridge site. • Execute shot peening along with re-painting works, which enable to make use of scaffolding and countermeasure against antiscattering of blasting for re-painting as ones for shot peening. • Collect and reutilize steel grits for shot peening by a newly developed circulating system. • Replace steel grits of blasting for painting with steel rounded grits for shot peening. • Develop execution and finished shape management methods for secure quality control. The repair work was completed in 2020.

Case: *Fatigue cracks in a non composite steel girder bridge (Japan)*	
Pictures of the new rehabilitation materials and technologies	  
3b) Which aspects were taken into account in the decision-making process while selecting the new rehabilitation materials and technologies.	For example: • Detours/Traffic impacts/Availability • Sustainability • Environmental (material/technology/others) • Method/Technique comparison • …

Case: *Fatigue cracks in a non composite steel girder bridge (Japan)*	
Answer	• High work efficiency because it is equally applicable to little spaces and wide area as blasting. • Less generation of industrial waste because it collects and reutilizes steel grits. • Better work environment because it uses non-crushable steel grids, and thus rarely generates dust. • Less cost and carbon dioxide emission accompanied by less disposal and transport of industrial waste.
3c) Have developments in materials and technology given rise to an environmental assessment?	Describe, if applicable, how the environmental assessment of the materials and technology used was carried out.
Answer	No
3d) Did the use of this innovative method helps to reduce traffic impact of the works?	Describe, if applicable, how this innovative method reduce the traffic impact of the works.
Answer	No
4a) Have you implemented any monitoring/testing/NDT of the rehabilitation after works?	Did you implement a monitoring of the bridge behaviour after the rehabilitation works? If any, please describe it.
Answer	Monitoring is currently in progress.
4b) What are the main conclusions of the monitoring?	Considering the observation period, what are the main conclusions of the monitoring related to the behaviour of the bridge?
Answer	Monitoring is currently in progress.
5a) Main benefits of the method?	From your point of view what are the main advantages of this method regarding cost, benefit, effectiveness, durability, traffic impact (capacity to accelerate the repair and/or to reduce traffic disruption), the environmental balance ... Including comparison with “more standard method” if any.

Case: *Fatigue cracks in a non composite steel girder bridge (Japan)*	
Answer	Anti-corrosion and fatigue measures can be implemented at the same time by applying shot peening along with blasting for re-painting. It is superior to a conventional method, weld grinding, which is difficult to apply to little spaces and needs proficiency of workers.
5b) Main disadvantages of the method?	From your point of view what are the main disadvantages of this method regarding cost, benefit, effectiveness, durability, traffic impact (increasing traffic disruption during works), the environmental balance … Including comparison with "more standard method" if any.
Answer	No
6) General appreciation of the method.	Give a global appreciation of the method
Answer	An experimental study using specimens showed that shot peening successfully introduced enough compressive residual stress and raised fatigue strength by 2 grades compared with one without shot peening. A field study at an actual bridge showed that shot peening introduced compressive residual stress up to 500μm deep.
7) References	Give some references if available (papers, website, public domain pictures …)

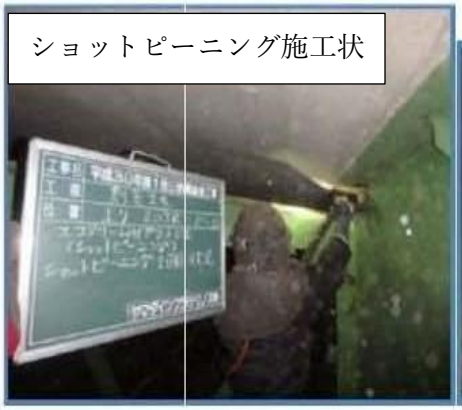
Case: *Fatigue cracks in a non composite steel girder bridge (Japan)*	
Answer	Koji Kinoshita, Ryoma Akiyama, Shohei Yamada, Mitsuru Handa. : Fatigue Strength Improvement of Welded Joints by Shot Peening. Proceedings of Constructional Steel, Vol.24, No.97, pp673-677, 2016 (in Japanese) Yuki Ono, Yuki Banno, Koji Kinoshita, Shohei Yamada, Yuya Nishiyama, Mitsuru Handa. : Suggestion of quality control method for Shot Peening for welded joints of existing steel bridges. Proceedings of 2018 JSCE Annual Meeting, pp.287-288, 2018 (in Japanese) Koji Kinoshita, Yuki Ono, Yuki Banno, Shohei Yamada, Mitsuru Handa. : Application of Shot Peening for welded joints of existing steel bridges. International Institute of Welding, IIW Document XII-2750-18, 2018 Koji Kinoshita, Yuki Banno, Yuki Ono, Shohei Yamada, Mitsuru Handa. : Fatigue Strength Improvement of Welded Joints of Existing Steel Bridges by Shot-Peening. International Journal of Steel Structures, Vol.19, No.2, pp495-503, 2019 Koji Kinoshita, Yuki Banno, Shohei Yamada, Seiji Kameyama, Fatigue Strength Improvement of Welded Joints of Existing Steel Bridges by Shot Peening. Proceedings of 2020 Annual Meeting of the Chubu branch of JSCE, pp.15-16, 2020 (in Japanese) Seiryo Sugawa, Koji Kinoshita, Shouhei Yamada, Seiji Kameyama: Fatigue Strength Improvement of Welded Joints of Existing Steel Bridges by Shot-Peening. Proceedings of 15th Annual Meeting of the Tokai branch of the Society of Materials Science (in Japanese) Kinoshita, K., Ono, Y., Banno, Y. Shohey Yamada, Mitsuru Handa. Application of shot peening for welded joints of existing steel bridges. Weld World 64, 647–660 (2020). https://doi.org/10.1007/s40194-020-00863-w https://www.kozobutsu-hozen-journal.net/walks/16302/ https://www.eco-yamadapeint.co.jp/service/hybrid.html

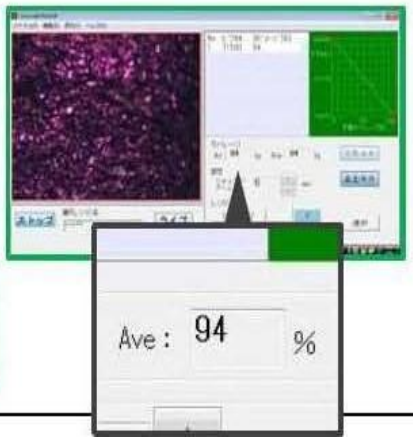
15.29. CASE 29: 非合成鋼桁橋の疲労き裂(日本)

Case: 非合成鋼桁橋の疲労き裂(日本)	
I) 橋の簡単な説明（タイプ、材質、工期等	橋の種類、材料(鋼、鉄筋コンクリート、プレストレストコンクリート、材木、レンガなど)、建設時間、スパンの長さなどを含む、橋の簡単な説明。
回答	上長窪支店(上下線) 橋形式:3+2+3 径間連続非合成鋼桁橋 橋長 300m。 主径間 37.5m 竣工年:1969 年
橋梁の写真	
2a) リハビリテーションの必要性の簡単な説明	橋のリハビリテーションが必要な理由の説明 劣化(種類)、サービスレベルの向上(例えば、耐荷重)
回答	老朽化と交通量の多さから,予防保全の観点より疲労き裂対策を行うこととした。

Case: *Fatigue cracks in a non composite steel girder bridge (Japan)*

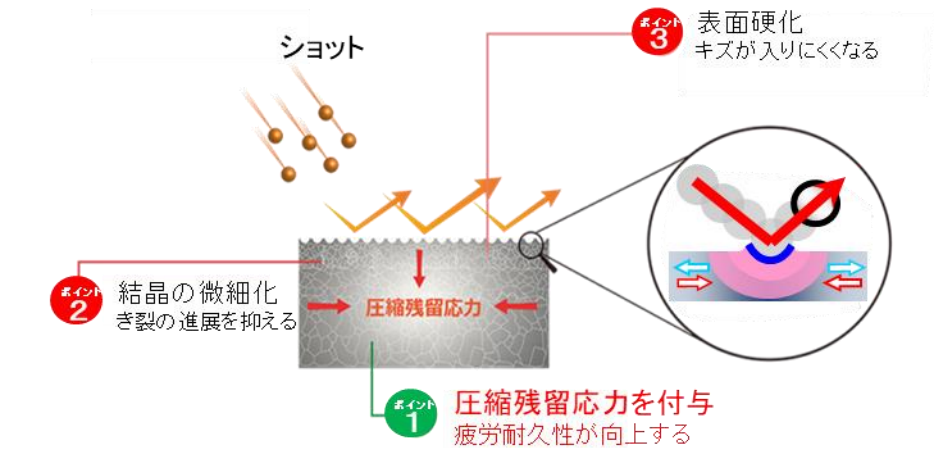
Picture

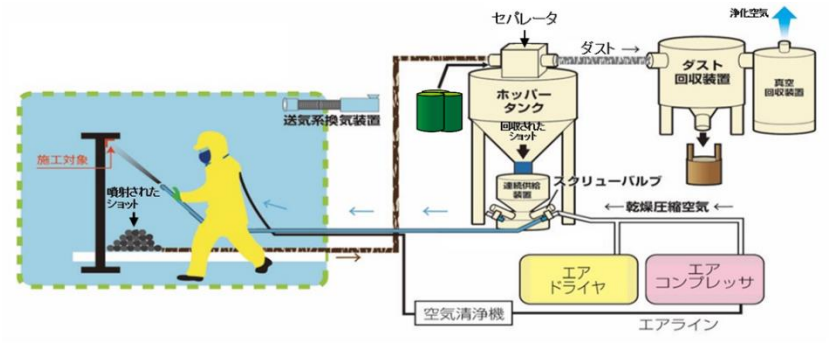


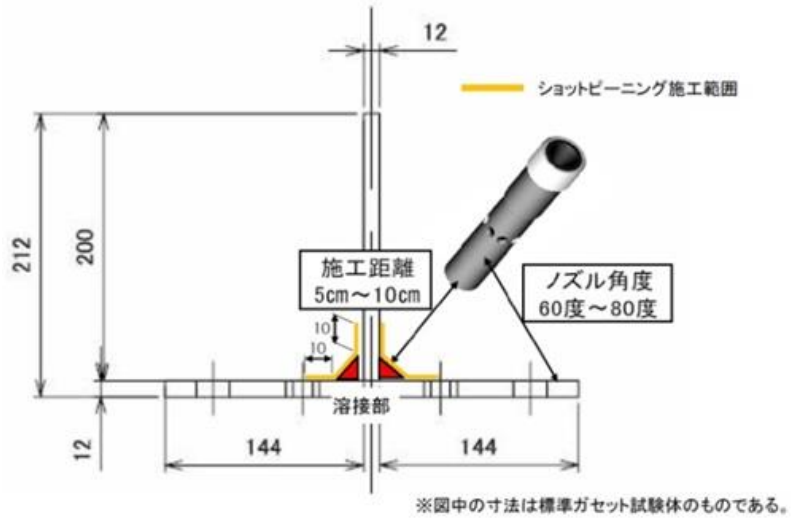


2b）このリハビリテーションの必要性は、気候変動の影響と関係	リハビリテーションの必要性は気候変動の影響に関連しているか? 例: ● 洪水のリスクが増大しているため、桟橋の洗掘保護を改善する。 ● 大雨が増えているので、排水能力を増やす。 ● 温度上昇のため、耐熱性の高い新しいアスファルト舗装を使用 関連してる場合は記載する
回答	関連していない
3a）新しいリハビリテーション材料や技術について説明	リハビリテーションの素材や技術について簡単に説明する。 完成年
回答	ショットピーニングは、疲労耐久性と応力腐食割れの耐久性を向上させる技術です。ショットピーニングは、スチールグリットとスチールショットを用いて,鋼材表面に微小な塑性変形と有益な圧縮残留応力を与える表面処理である.表面の結晶粒を微細化することにより、亀裂の進展を防止します。また、表面を硬化させることにより、キズの発生を防止します。 大規模な飛散防止対策が必要であることや,研削材の回収･再利用が困難であることなどから，橋梁現場ではなく工場でのみショットピーニングは適用されてきた。しかし、以下の対策により、既存の橋梁現場での適用が可能となった。 ● 塗替塗装工事と同時にショットピーニングを実施することで、塗替塗装の足場やブラスト飛散防止対策もショットピーニング時に利用することができる。 ● 新開発の循環式ブラストのシステムによりショットピーニング用ショットを回収し、再利用します。 ● 塗装用ブラストのスチールグリットをショットピーニング用の丸形スチールショットに交換する。 ● 確実な品質管理のための施工・仕上がり形状管理手法の開発した 2020 年に改修工事が完了した。

新しいリハビリテーション素材と技術の写真







3b) 新しいリハビリテーション技術の材料や技術を選択する際、意思決定プロセスにおいてどのような点が考慮されたのか。	例 ● 迂回/トラフィックへの影響/可用性 ● 持続可能性 ● 環境(材料・技術・その他) ● 方法/技術の比較
回答	● ブラスト処理と同様に狭隘部や広い範囲に適用できるため、作業効率が高い。 ● スチールグリットを回収して再利用するため、産業廃棄物の発生が少ない。 ● 破砕しにくいスチールグリットを採用しているので、粉塵の発生が少なく作業環境が良好。 ● 産業廃棄物の処分・運搬の削減に伴うコストと二酸化炭素排出量が削減される。
3c) 材料や技術の発展により環境アセスメントが必要になったことがありますか?	該当する場合は、使用された材料および技術の環境評価がどのように実施されたかを記述。
回答	実施されていない
3d) この革新的な方法の使用は、作業の交通への影響を軽減するのに役立ちましたか?	適用可能な場合は、この革新的な方法が作業の交通への影響をどのように軽減するかを説明する。
回答	なし
4a) 工事後のリハビリのモニタリング、テスト、非破壊検査を実施しましたか?を実施しましたか?	改修工事後,橋の挙動をモニタリングしたか 実施した場合,その項目
回答	モニタリングは進行中です
4b) モニタリングの結果は?	観測期間を考慮して、橋の挙動に関するモニタリングの主な結論は?
回答	モニタリングは現在進行中

5a この工法の主な利点は何か	コスト、利益、効果、耐久性、交通への影響(作業中の交通混乱の増加)、環境バランスの観点に対して、この方法の主な利点は何か説明 「より標準的な方法」との比較がある場合はそれも含む。
回答	ショットピーニングとブラストを併用して再塗装することにより、防食と疲労対策を同時に行うことができる。 狭隘部施工が困難で,作業者の熟練度が必要になる従来の溶接止端部のグラインダ処理に比べ優れている
5b) この工法の主な欠点は?	コスト、利益、効果、耐久性、交通への影響(作業中の交通混乱の増加)、環境バランスの観点に対して、この方法の主な欠点は何か? 「より標準的な方法」との比較がある場合はそれも含む。
回答	なし
6) 工法の一般的な評価。	工法の世界的な評価
回答	試験片を用いた実験では、ショットピーニングにより十分な圧縮残留応力を導入することができ、ショットピーニングなしの場合と比較して疲労強度を 2 段階向上させることができた。 実橋での現地調査では,ショットピーニングにより深さ 500μm までの圧縮残留応力が導入されることを示した。

7) レファレンス	参考文献をいくつか挙げる（論文、ウェブサイト等
回答	Koji Kinoshita, Ryoma Akiyama, Shohei Yamada, Mitsuru Handa. ：Fatigue Strength Improvement of Welded Joints by Shot Peening. Proceedings of Constructional Steel, Vol.24, No.97, pp673-677, 2016 (in Japanese) Yuki Ono, Yuki Banno, Koji Kinoshita, Shohei Yamada, Yuya Nishiyama, Mitsuru Handa. ：Suggestion of quality control method for Shot Peening for welded joints of existing steel bridges. Proceedings of 2018 JSCE Annual Meeting, pp.287-288, 2018 (in Japanese) Koji Kinoshita, Yuki Ono, Yuki Banno, Shohei Yamada, Mitsuru Handa. Application of Shot Peening for welded joints of existing steel bridges. International Institute of Welding, IIW Document XIl-2750-18, 2018 Koji Kinoshita, Yuki Banno, Yuki Ono, Shohei Yamada, Mitsuru Handa. Fatigue Strength Improvement of Welded Joints of Existing Steel Bridges by Shot-Peening. International Journal of Steel Structures, Vol. 19, No.2, pp495503, 2019 Koji Kinoshita, Yuki Banno, Shohei Yamada, Seiji Kameyama, Fatigue Strength Improvement of Welded Joints of Existing Steel Bridges by Shot Peening. Proceedings of 2020 Annual Meeting of the Chubu branch of JSCE, pp.15-16, 2020 (in Japanese) Seiryo Sugawa, Koji Kinoshita, Shouhei Yamada, Seiji Kameyama: Fatigue Strength Improvement of Welded Joints of Existing Steel Bridges by ShotPeening. Proceedings of 15th Annual Meeting of the Tokai branch of the Society of Materials Science (in Japanese) Kinoshita, K., Ono„ Y., Banno, Y. ShoheyYamada, Mitsuru Handa. Application of shot peening for welded joints of existing steel bridges. Weld World 64, 647-660 (2020). https://doi.org/10.1007/s40194-020-00863-w https://www.kozobutsu-hozen-journaI.net/walks/16302/ https://www.eco-yamadapeint.co.jp/service/hybrid.html