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(57) **Abrégé/Abstract:**

A method for restoring a worn rail clip shoulder located on a concrete rail tie. The method comprises applying a polymeric material to the worn rail clip shoulder located on the concrete rail tie; and restoring the worn rail clip shoulder by curing the polymeric material. The polymeric material is substantially sag resistant and maintains its shape without substantial runoff from the concrete rail tie during the restoring of the worn rail clip shoulder.



ABSTRACT

A method for restoring a worn rail clip shoulder located on a concrete rail tie. The method comprises applying a polymeric material to the worn rail clip shoulder located on the concrete rail tie; and restoring the worn rail clip shoulder
5 by curing the polymeric material. The polymeric material is substantially sag resistant and maintains its shape without substantial runoff from the concrete rail tie during the restoring of the worn rail clip shoulder.

RESTORING WORN RAIL CLIP SHOULDERS ON CONCRETE RAIL TIES

BACKGROUND

5 This relates to methods and materials for restoring worn rail clip shoulders located on concrete rail ties.

Conventionally, rails are held to concrete rail ties by rail clips or fasteners that bear down on the rail flange. These rail clips or fasteners are typically fabricated of metal and include a shoulder portion.

10 Concrete rail ties have been found to be prone to wear particularly in sandy and wet locations or on steep grades where locomotives use sand for traction. More specifically, a rail shoulder is disposed on a rail tie. The tie is surrounded by ballast. The rail clip shoulders are embedded in the concrete tie and adapted to hold the rail clips that bear down on the flange of the rail.

15 Worn shoulders on concrete rail ties need to be repaired quickly enough to limit hold up of train traffic to an acceptable time. Worn shoulders also need to be restored to their original dimensions.

Conventionally, when a rail clip shoulder has become unduly worn, the entire shoulder is removed and replaced with a new shoulder. The new shoulder
20 is secured in place, typically by a curable epoxy resin material. However, even when applied in a relatively thin layer, the cure time for epoxy resins can take 12 to 36 hours at typical ambient temperatures. This is completely unacceptable from a train operator's point of view.

If the trains are running even slowly over the freshly replaced rail
25 shoulders, and if the epoxy is still in a plastic state, it will run-off. This results in improper bonding of the new shoulder to the concrete rail tie.

SUMMARY

As stated above, in the past worn rail clip shoulders are replaced by new
30 rail clip shoulders. When epoxy resins are used in the new rail clip shoulder replacement process, a number of problems will result. Conducting the rail tie

shoulder repair in the field by laborers who are not trained for conducting this epoxy material application work is arduous at best. Curing an epoxy resin over a wide range of humidity's, temperatures and pressures is difficult to implement. Therefore, replacing a rail tie shoulder in a commercial time frame is hard to
5 consistently accomplish. Restoring a worn shoulder presents an even bigger problem. This is because the shoulder is a vertically-extending member and quite problematical to restore.

Pre-catalyzed mercaptan-based epoxy hardeners are commonly required in epoxy formulations. It is difficult for these products to cure under cold climatic
10 conditions. These mercaptan-based hardeners also have a very obnoxious odor and workers often complain of becoming nauseous when working with these products. Repairing a rail tie with an epoxy resin does not result in a refurbished product wherein superior performance under dynamic operating condition can be maintained. The use of an epoxy resin does not result in a rail tie that exhibits a
15 high level of durability under load so that maintaining the gauge of a rail assembly is a problem. The use of an epoxy resin does not result in a rail tie that exhibits a high level of fracture resistance under load so that maintaining the gauge of a rail assembly cannot be accomplished. The high viscosity of an epoxy resin makes handling more complicated when it is dispensed, particularly in the field.

20 It has now been determined that polymeric materials can be employed to restore a worn rail clip shoulder. In an embodiment herein the polymeric materials can comprise, and in another embodiment can consist essentially of, at least one of a polyurethane, a polyurea and/or a poly(urethane-urea) polymer. Thus, when these polymeric materials are use a number of advantages will result.
25 The method comprises applying a polymeric material as described above to the worn rail clip shoulder located on the concrete rail tie. Then, the polymeric material is cured so it adheres to the worn rail clip shoulder where it is restored. The polymeric material is substantially sag resistant and exhibits excellent

pseudoplasticity. Therefore, the polymeric material maintains its shape without substantial runoff from the concrete rail tie during the restoration operation.

In an embodiment, the damaged rail shoulder is restored using non-ambient heat.

5 In one embodiment the damaged rail shoulder is restored using non-ambient heat for curing the polymeric material. Furthermore, in another embodiment, the worn rail clip shoulder is restored without requiring the use of non-ambient pressure. Accordingly, the subject restoration method is more easily performed in the field by laborers who are employed for this purpose.

10 The worn rail clip shoulder in an embodiment herein has an extremely short Gel Time. In a further embodiment, the gel time of the polymeric material is not more than about five seconds, and in still a further embodiment not more than about three seconds, and in still another embodiment not more than about one second. This allows for placement and retention of the rail shoulder components on the repair site
15 without substantial run-off of the polymeric material from the repair site. In other words, the worn rail clip shoulder and the polymeric material can be maintained in a fixed position on the surface of the concrete rail tie during the course of the worn rail clip shoulder restoration procedure.

The Set Time of the polymeric material can also be sufficient to permit
20 contouring of the worn rail clip shoulder in situ in the repair area using application techniques that can be readily performed by workers in the field. In an embodiment herein, the Set Time of the polymeric material is sufficient for contouring the restored worn rail clip shoulder without requiring the use of non-ambient pressure. Set Time is typically dependent upon temperature conditions and the thickness of
25 applied polymeric material.

The rail tie properties can be maintained over a wide range of ambient temperatures during use. These ambient temperature are preferably up to at least about 120 °F, more preferably to at least about 140 °F, and most preferably up to at least about 160 °F, and as low as -50 °F, more preferably as low as about -25 °F, and
30 most preferably as low as about 0 °F.

In the method of this invention, curing of the polymeric material during repair of the worn rail clip shoulder can be accomplished over a wide range of humidity's, temperatures and pressures. Therefore, an effective rail tie shoulder can be produced in a commercial time frame.

5 There is no substantial obnoxious odor emitted with the subject polymeric material. Thus, a worker in the field does not have to deal with odor problems which plague prior art repair products.

 Repairing a worn rail clip shoulder with the subject polymeric material results in a refurbished product wherein superior performance under dynamic
10 operating conditions is maintained so that a high level of durability under load can be provided while maintaining the gauge of a rail assembly. The modulus of the polymeric material used to repair the rail clip shoulder can also be increased to a level which will resist compressive loading and maintain the rail gauge of the rail assembly.

15 The polymeric material displays a high degree of toughness and ductility. Material toughness is indicated by area under stress-strain curve developed during tensile testing. Toughness-ductility classifications depend on the Elastic Modulus (Young's Modulus), tensile strength, and elongation. Rigid materials have an Elastic Modulus (E) that is defined as $E > 700 \text{ Mpa}$. Brittle materials have an
20 elongation less than 10%, in the case of epoxy materials an elongation of about 5%. Ductile materials have an elongation as defined below of at least about 10% or higher. The percent elongation value of the restored rail clip shoulder can be increased to a level that results in increased brittle fracture morphology. In one embodiment, the restored rail clip shoulder can provide an increased percent
25 elongation value that results in substantially improved material durability.

 Verification of the structural differences in durability of conventional epoxy resins and the subject polymeric material can be established by, for example, comparing the elongation ("Elongation") of each of the respective materials under tensile loading (ASTM D 638). Typically, conventional epoxy polymers show poor

elongation properties (Elongation > 5%) and exhibit a corresponding brittle fracture morphology. Contrarily, the Elongation of the polymeric material employed herein is preferably at least about 10%, more preferably at least about 15%, and most preferably at least about 20%.

5 The subject polymeric material also has a modulus that is in the rigid class of materials, a greater area under the stress strain curve, a substantial plastic energy of deformation term, and a lower filler loading that is enhanced by excellent bonding of the polymer matrix to the filler, minimizing internal defects and the size of the internal defect. Typical epoxy systems are highly filled and
10 have nominal matrix-filler bonding resulting in numerous internal defects of considerable size.

 The restored rail clip shoulder forms a rail tie, which can exhibit a high level of fracture resistance under load while maintaining the gauge of a rail assembly. This improved fracture resistance is evidenced by the presence of a
15 higher level of mechanical properties, better SEM image analysis results, and an enhanced Griffith fracture analysis.

 The Tensile Strength (ASTM D638M-89) of the restored rail clip shoulder is generally at least equivalent to that of epoxy resins used conventionally. In one embodiment, the Tensile Strength of the polymeric material employed herein is at
20 least about 3,800 psi, in another embodiment at least about 4,200 psi, and in still another embodiment at least about 4,500 psi.

 The polymeric material of the restored rail clip shoulder is also characterized by an increase in the Young's Modulus of the polymeric material of the restored rail clip shoulder. In one embodiment, the Young's Modulus of the
25 polymeric material employed herein is at least about 700 Mpa, in another embodiment at least about 850 Mpa, and in still another embodiment at least about 1,000 Mpa.

 This polymeric material is also characterized by exceptional adhesion to the materials used to construct the rail clip shoulders on the concrete railroad ties,

typically, stainless steel or ductile iron. It also shows outstanding adhesive properties for binding to shims, typically fabricated of stainless steel, which are used in the repair process to reinforce the restored rail clip shoulder. This adhesion property can be measured by employing several testing regimes.

For example, the adhesion to stainless steel can be measured using a lap shear test (ASTM 3631). In this embodiment, the minimum adhesion of the polymeric material employed herein is at least about 1500 lbs/in², in another embodiment at least about 1800 lbs/in², and in still another embodiment at least about 2000 lbs/in².

A pull off test for adhesion to stainless steel or ductile iron can be employed according to ASTM D4541. In an embodiment using stainless steel, the minimum adhesion of the polymeric material employed herein is at least about 1600 lbs/in², in another embodiment at least about 1800 lbs/in², and in still another embodiment at least about 2000 lbs/in². In an embodiment using ductile iron, the minimum adhesion of the polymeric material employed herein is at least about 2500 lbs/in², in another embodiment at least about 2800 lbs/in², and in still another embodiment at least about 3000 lbs/in².

A lowered viscosity of the subject polymeric material is provided. This property of the polymeric material makes handling less complicated when it is dispensed, particularly in the field.

According to one aspect of the present invention, there is provided a method for restoring a worn rail clip shoulder located on a concrete rail tie, which comprises applying a polymeric material to a worn area of the worn rail clip shoulder located on the concrete rail tie; and restoring the worn area by curing the polymeric material so it adheres to the worn rail clip shoulder, the polymeric material being substantially sag resistant, and substantially maintaining the original shape of the rail clip shoulder, without substantial runoff from the concrete rail tie during said restoring of the worn rail clip shoulder.

According to a further aspect of the present invention, there is provided a method for restoring a worn rail clip shoulder located on a concrete rail tie, which comprises applying a polymeric material to a worn area of the worn rail clip shoulder located on the concrete rail tie; and restoring the worn area by curing the polymeric material so it adheres to the worn rail clip shoulder, the polymeric material being

substantially sag resistant, and substantially maintaining the original shape of the rail clip shoulder, without substantial runoff from the concrete rail tie during said restoring of the worn rail clip shoulder.

According to a further aspect of the present invention, there is provided a method for restoring a worn rail clip shoulder located on a concrete rail tie, which comprises applying a polymeric material comprised of a polyurethane, polyurea or poly(urethane-urea) material and introducing a shim to the worn area of the worn rail clip shoulder located on the concrete rail tie; and restoring the worn area by curing the polymeric material so it adheres to the worn rail clip shoulder and so that it secures the metal shim to the worn rail clip shoulder, respectively, the polymeric material being substantially sag resistant and maintaining its shape without substantial runoff from the concrete rail tie during said restoring of the worn rail clip shoulder.

DETAILED DESCRIPTION

Polymeric materials particularly useful in this invention can be prepared from various combinations of amine-terminated and/or hydroxyl-terminated resins that are reacted with an isocyanate material. These polymeric materials in one embodiment comprise at least one polyol compound and/or at least one amine compound, and an isocyanate.

If the polymeric material is a poly(urethane-urea), in one embodiment it can be formed employing (a) at least one polyol compound, typically a hydroxyl

capped polyol and/or a hydroxyl chain extender, in one embodiment an amount from about 20 %, in another embodiment from about 25 %, and in a further embodiment from about 30 %, in an embodiment herein up to about 60 %, in still another embodiment up to about 55 %, and in still a further embodiment up to about 45 %, (b) at least one amine compound, typically an amine chain extender, in one embodiment from about 0.5 %, in another embodiment from about 1.0 %, and in still another embodiment from about 1.5 %, in one embodiment up to about 20 %, in further embodiment up to about 15 %, and in still a further embodiment up to about 10 %, and (c) an isocyanate compound, typically an isocyanate prepolymer, in one embodiment an amount from about 20 %, in another embodiment from about 25 %, and in still another embodiment from about 30 %, in one embodiment up to about 45 %, in a further embodiment up to about 40 %, and in still a further embodiment up to about 35 %.

If the polymeric material is a polyurethane, in one embodiment it can be formed employing (a) at least one polyol compound, typically a hydroxyl capped polyol and/or a hydroxyl chain extender, in one embodiment an amount from about 55 %, in another embodiment from about 60 %, and in a further embodiment from about 65 %, in an embodiment herein up to about 80 %, in still another embodiment up to about 75 %, and in still a further embodiment up to about 70 %, and (b) an isocyanate compound, typically an isocyanate prepolymer, in one embodiment an amount from about 20 %, in another embodiment from about 25 %, and in still another embodiment from about 30 %, in one embodiment up to about 45 %, in a further embodiment up to about 40 %, and in still a further embodiment up to about 35 %.

If the polymeric material is a polyurea, in one embodiment it is formed employing (a) at least one amine compound, typically an amine capped compound and/or an amine chain extender, in one embodiment an amount from about 55 %, in another embodiment from about 60 %, and in a further embodiment from about 65 %, in an embodiment herein up to about 80 %, in still another embodiment up

to about 75 %, and in still a further embodiment up to about 70 %, and (b) an isocyanate compound, typically an isocyanate prepolymer, in one embodiment an amount from about 20 %, in another embodiment from about 25 %, and in still another embodiment from about 30 %, in one embodiment up to about 45 %, in a
 5 further embodiment up to about 40 %, and in still a further embodiment up to about 35 %.

Typical polyol compounds can be hydroxyl capped di- and tri-functional polyether oxides, hydroxyl capped polypropylene oxides, hydroxyl capped di- and tri-functional polyethylene oxides, hydroxyl capped di- and tri-functional
 10 poly(propylene-ethylene)oxides, and hydroxyl capped di- and tri-functional polyesters. Examples of polyols which can be employed herein are Bayer LHT-^{*} 240, PPG-425, Arch 20-280^{*}, Dow Voranol 230-238^{*}, and BASF Quadrol^{*}. In one embodiment the polyol compound has a molecular weight of from about 200 grams/mol, and in another embodiment from about 300 grams/mol, and in still
 15 another embodiment from about 400 grams/mol, and in a certain embodiment up to about 4,000 grams/mol, in another embodiment up to about 3500 grams/mol, and in still another embodiment up to about 3000 grams/mol.

Typical amine compounds can be amine compounds such as amine chain extenders including di- and tri-polyoxypropylenediamines, liquid aromatic
 20 diamines, isophronediamine, and diethylenetriamine or amine capped compounds such as amine capped bi- or tri-functional amine compounds. Examples of amines which can be employed herein are Shell Epi-Cure 3271^{*}, Vestamine IPD, Huntsman D-230^{*}, and Dorf Ketal Unilink 4100.

Typical isocyanate compounds are di- and tri-functional aromatic
 25 isocyanates, polymeric modified 4,4-diphenylmethane diisocyanates, and 1,6-hexamethylene diisocyanates (aliphatic isocyanates). Examples of isocyanates which can be employed herein are Bayer Desmodure N 3400^{*}, ICI Rubinate^{*} 1209, Bayer Mondur ML^{*}, Bayer Mondur MR^{*} and MR Light^{*}. Also, the isocyanate compound can be a prepolymer isocyanate blend such as Bayer Mondur MA-

2300, Bayer Mondur^{*}MA-2600, and Baytec^{*}ME-040. The functionality of the isocyanate in one embodiment can be at least about 2.0, in another embodiment at least about 2.2, in a further embodiment at least about 2.4, and in still a further embodiment up to about 2.6.

5 The polyurethane, and poly(urethane-urea) reactions can include a catalyst system to accelerate the reaction between the isocyanate and the hydroxyl groups of each polyol. These catalysts can include tin, mercury, lead, bismuth, zinc and various amine compounds such as are described in U.S. 5,011,902. A preferred catalyst employed herein is a metal carboxylate.

10

In certain instances it may be desirable to add a chain extender to complete the formulation of polyurethane, polyurea, and poly(urethane-urea) polymers by reacting isocyanate groups of adducts or prepolymers. Examples of some types of polyol and amine chain extenders include 1,3-butanediol, 1,4-butanediol, 2-ethyl-
 15 1,3-hexanediol, diethylene glycol, trimethylol propane and hydroquinone di(beta hydroxyethyl ether). The subject polyurethane, polyurea, and poly(urethane-urea) compositions may additionally incorporate diluents, fillers, compatibilizers, thixotropes, pigments, plasticizers, colorants, de-foaming agents, rheological modifiers, and anti settling agents. Suitable fillers include barium sulfate, calcium
 20 sulfate, calcium carbonate, silica, and clay particles, such as aluminum silicates, magnesium silicates, ceramic and glass micro-spheres and kaolin. Suitable compatibilizers are hydroxy containing organic compounds, preferably hydroxy containing monocyclic arenes such as ethoxylated nonyl phenol, which compatibilize the polyol and aromatic diisocyanate reactants in the formulation.
 25 Suitable diluents include hydrotreated paraffinic oils, phthlates, carbonates, hydrotreated naphthenic oils, petroleum solvents, aliphatic solvents and propylene carbonate.

Equipment for dispensing the isocyanate and polyol(s)/amines employed in producing the polyurethane, polyurea, and poly(urethane-urea) materials, such as

the Mixus™ dispensing equipment manufactured by Willamette Valley Company of Eugene, Oregon, is commercially available. Typically, the two components which form the subject polyurethane, polyurea, and poly(urethane-urea) filler materials are pumped from storage tanks to a proportioning unit where the

5 components are measured out according to a specified ratio. A known amount of each material is then separately pumped to a dispensing unit. The components are mixed in the dispensing unit and then introduced into the worn area of the shoulder of the railroad tie. The components of the polymeric materials can also be mixed together using a cartridge system with a static mixing tube along with

10 standard proportioning equipment.

The shoulder repair process takes place during normal re-gauging and maintenance operations or during a dedicated shoulder repair process. The repair process is generally as follows:

- 15 1. The rail is removed.
2. Pressurized air, either from a compressor or blower, is used to clear the area of debris.
3. Pads can be removed, though this depends on the extent of the maintenance operation.
- 20 4. The shoulder is cleaned with a wire brush or grinding wheel.
5. A polymeric material such as described above is applied to the recess site in the rail tie shoulder. Alternately, the polymeric material is applied to a shim.
6. If a shim is employed, it is put in place on the edge of the shoulder.
- 25 7. The rail is re-assembled.

It is to be understood that the above-referenced arrangements are only illustrative of the application for the principles of the present invention. Numerous modifications and alternative arrangements can be devised without departing from

the scope of the present disclosure. While embodiments of the present invention have been shown in the drawings and fully described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiment(s) of the invention, it will be apparent to those of
5 ordinary skill in the art that numerous modifications can be made without departing from the principles and concepts as set forth herein.

WHAT IS CLAIMED IS:

1. A method for restoring a worn rail clip shoulder located on a concrete rail tie, which comprises
 applying a polymeric material to a worn area of the worn rail clip shoulder
 5 located on the concrete rail tie; and
 restoring the worn area by curing the polymeric material so it adheres to the worn rail clip shoulder, the polymeric material being substantially sag resistant, and substantially maintaining the original shape of the rail clip shoulder, without substantial runoff from the concrete rail tie during said restoring of the worn rail clip
 10 shoulder.
2. The method of claim 1, which further includes the step of using non-ambient heat for curing the polymeric material.
3. The method of claim 1, wherein the worn rail clip shoulder is restored without requiring the use of non-ambient pressure.
- 15 4. The method of claim 1, wherein the Gel Time of the polymeric material is not more than about five seconds.
5. The method of claim 1, wherein the polymeric material comprises at least one of a polyurethane, a polyurea and/or a poly(urethane-urea) polymer.
6. The method of claim 1, wherein the Set Time of the polymeric material
 20 is sufficient for contouring the worn rail clip shoulder in situ so it attains substantially its original shape.
7. The method of claim 1, wherein the rail ties having the restored rail clip shoulder maintains the gauge of a rail assembly under dynamic operating conditions.
- 25 8. The method of claim 1, wherein the modulus of the restored rail clip shoulder is increased to a level which will resist compressive loading and maintain the rail gauge of the rail assembly.
9. The method of claim 1, wherein the Elongation of the polymeric material of the restored rail clip shoulder is at least about 10%.
- 30 10. The method of claim 1, wherein the Tensile Strength of the polymeric material of the restored rail clip shoulder is at least about 3800 psi.
11. The method of claim 1, wherein the Young's Modulus of the polymeric

material of the restored rail clip shoulder is at least about 700 Mpa.

12. The method of claim 1, wherein the Degree of Adhesion of the polymeric material to the restored rail clip shoulder is at least about 1500 lbs/in².

13. The method of claim 1, wherein the worn rail clip shoulder is restored
5 using non-ambient heat.

14. A method for restoring a worn rail clip shoulder located on a concrete rail tie, which comprises

applying a polymeric material comprised of a polyurethane, polyurea or poly(urethane-urea) material and introducing a shim to the worn area of the worn rail
10 clip shoulder located on the concrete rail tie; and

restoring the worn area by curing the polymeric material so it adheres to the worn rail clip shoulder and so that it secures the metal shim to the worn rail clip shoulder, respectively, the polymeric material being substantially sag resistant and maintaining its shape without substantial runoff from the concrete rail tie during said
15 restoring of the worn rail clip shoulder.