

METHOD FOR WORKING A THREAD ON A REINFORCING BAR FOR REINFORCEMENT OF CONCRETE

FIELD OF THE INVENTION

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The present invention relates to a reinforcing bar for use in reinforced concrete. More particularly, the present invention relates to a method for working a thread on reinforcing bars for use in reinforced concrete.

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BACKGROUND OF THE INVENTION

Reinforcing bars or rebar for use in reinforced concrete are well known. At construction sites and civil engineering works where concreting is required, concrete structures are generally reinforced with reinforcing bars to provide added strength and stability. Such rods are placed within reinforced concrete, such as pre-stressed concrete, to enhance the strength of a given concrete structure.

A reinforcing bar is typically a steel bar manufactured with surface deformations, such as ribs and fins to provide a locking anchorage with the surrounding concrete, and is also known as a "deformed bar". These deformed bars have one or more series of parallel transverse ribs that extend around the circumference of the bar. In addition, the bars may have longitudinal ribs known generally in the art as fins, which are formed during the manufacturing process. The transverse ribs may extend perpendicularly between the fins. Alternatively, the transverse ribs may be set in an inclined manner so as to extend at a non-perpendicular angle from the longitudinal fins.

Reinforcing bars or deformed bars are supplied in pre-cut lengths and accordingly, it may be necessary to connect several bars end to end for use depending upon the size of the construction work. Reinforcing bars are frequently connected to one another to permit the transfer of force between them. Thus, short reinforcing bars can be used in larger concrete structures. One method of connecting such bars is to ensure that they are positioned so as to overlap such that there is force transfer from one bar to another through the concrete surrounding them. In practice, this

- method known as lap splicing or lap jointing is not desirable. Specifically, according to this method, in practice two reinforcing bars of similar size would have to be tied together using steel wires at their ends. This consequently requires a large overlap of the reinforcing bars to ensure structural integrity of the joint formed utilizing the steel wires, and thereby results in material wastage and depending on the quality of the knots formed using the steel wires, may also result in a needless compromise of structural integrity of the resultant amalgamated reinforcing bar. Another method of connecting reinforcing bars is to weld them directly together. In this instance, the distance between the bars is shorter and the bars transfer force directly through the weld. The practice of welding reinforcing bars together is also usually avoided because the concrete and the reinforcing bar in the final piece will expand and contract at different rates, so having the rebar welded together creates pressure points where the concrete can crack.
- Yet another method of connecting reinforcing bars end to end is through the use of a mechanical sleeve coupler having threads disposed on its inner circumferential surface. According to this method of connecting reinforcing bars end to end, a connection end portion of a reinforcing bar is machined to form threads on said connection end portion. Two such similarly machined reinforcing bars which have been machined to have connection end portions disposed with threads are then mechanically coupled together using a connection sleeve or coupler disposed at its inner circumferential surface with threads that are complimentary to the threads formed on the connection end portions of said machined reinforcing bars. Despite being capable of forming a joint between reinforcing bars resulting in a spliced reinforcing bar structure having desirable structural characteristics for use in reinforcement of larger concrete structures, the primary disadvantage with the use of mechanical sleeve couplers or tapped couplers is associated with the cost of machining threads at the connection end portions of the reinforcing bars to be spliced. Nevertheless, this method of connecting reinforcing bars appears to be the most promising with regard to labour and cost advantages, as well as structural and mechanical properties of the resulting reinforcing bar structure that results from the splicing of two reinforcing bars, as opposed to methods of welding and lap jointing of reinforcing bars.

Conventional methods of forming threads at a connection end portion of a reinforcing bar, suffer from disadvantages that arise from machining steps that entail hot working and removal of material from the connection end portion, among others. Specifically, prior to machining threads onto a connection end portion of a reinforcing bar, the ribs and fins which represent surface deformations on the connection end portion have to be removed or eliminated to form a relatively smooth outer circumferential surface in order to allow machining of threads that do not compromise the strength of the joint formed between the threaded connection end portion and the mechanical sleeve coupler. In order to remove aforementioned surface deformations, some prior art methods may entail hot-working in which the connection end portion of the reinforcing bar is axially upset and shaped so as to remove the surface deformations. This method however suffers from the disadvantage that the material structure of the heated connection end portion of the reinforcing bar differs from the material structure of the remaining un-heated portion of the reinforcing bar, resulting in weakened impact absorption at the connection end portion. Another method commonly employed to remove surface deformations from the connection end portion of a reinforcing bar is by way of grinding. Grinding however results in material removal from the connection end portion and therefore may also result in weakening of the connection end portion and thus weakening of the joint formed by the subsequently threaded weakened connection end portion. In order to overcome the disadvantages of the methods for removing surface deformations from the connection end portion of a reinforcing bar, a cold working process can be conceived which eliminates the need for localized heating of the reinforcing bar leading to inconsistent material structure of the reinforcing bar, as well as material removal, both of which may result in a weakened threaded connection end portion.

Another disadvantage of conventional methods of forming threads on a connection end portion of a reinforcing bar results from the machining of the connection end portion to form threads thereon, once its surface deformations have been eliminated. Specifically, conventional machining of the connection end portion to form threads once the surface deformations have been eliminated comprises a step of cut-threading. Cut-threading, like the previously mentioned process of grinding to remove surface deformations, results in removal of material from the connection

end portion, thus resulting in weakening of the reinforcing bar at the connection end portion and is therefore not desirable.

Accordingly, it would be desirable if a method for working a connection end portion of a reinforcing bar which mitigates if not eliminate any or all of the problems elucidated above, be conceived.

SUMMARY OF THE INVENTION

10 The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is not intended to identify key/critical elements of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is
15 presented later.

In one aspect, the present invention provides a method for forming a thread on a connection end portion of a reinforcing bar having ribs and fins for reinforcing concrete which allows a formation of a joint by splicing two reinforcing bars end to
20 end, via a mechanical sleeve coupler having a thread at an inner circumferential surface, each reinforcing bar having a connection end portion that has been threaded with a thread complimentary to the thread disposed at the inner circumferential surface of the mechanical sleeve coupler; wherein the method comprises:

25 a step of facing and chamfering an end face of the connection end portion to remove surface irregularities present on the end face and thereby provide a substantially smooth and level end face of the connection end portion;

30 a step of primary cold-working to effect axial upsetting of the connection end portion of the reinforcing bar, such that a diameter of the connection end portion of the reinforcing bar is increased relative to the nominal diameter **D** of the reinforcing bar;

a step of secondary cold-working the connection end portion obtained from the step of primary cold-working, such that the diameter of the connection end portion of the reinforcing bar is decreased relative to its diameter after primary cold-working to effectively flatten protuberances due to the ribs and fins of the reinforcing
5 bar at the connection end portion; and

a step of roll-threading to form a thread on the connection end portion of the reinforcing bar, such that the diameter of the thread as measured from one crest to another crest disposed in symmetrical opposition along a circumferential surface of
10 the connection end portion, is larger than the nominal diameter of the reinforcing bar.

In accordance to an embodiment of the present invention, the step of primary cold working is a step of cold-forging executed by way of a cold forging die. In
15 accordance to a preferable embodiment, the step of primary cold working is a step of impression cold forging executed by way of an impression cold forging die.

In accordance to a preferable embodiment of the present invention, the step of secondary cold working is a step of extruding the connection end portion obtained
20 from the step of primary cold working such that the diameter of the connection end portion of the reinforcing bar is decreased relative to its diameter after primary cold working to effectively flatten protuberances due to the ribs and fins of the reinforcing bar at the connection end portion. In accordance to said preferable embodiment of the present invention, the step of extruding the connection end portion of the
25 reinforcing bar comprises urging said connection end portion through a squeezing die.

In accordance to an embodiment of the present invention, the step of primary cold-working to effect axial upsetting of the connection end portion of the reinforcing bar,
30 such that the diameter of the connection end portion of the reinforcing bar is increased, is a step in which the diameter of the connection end portion of the reinforcing bar is increased by 10% to 25% relative to the nominal diameter of the reinforcing bar, prior to said step of primary cold working.

In accordance to an embodiment of the present invention, the step of secondary cold working the connection end portion obtained from the step of primary cold working such that the diameter of the connection end portion of the reinforcing bar is decreased, is a step in which the diameter of the connection end portion of the reinforcing bar is decreased by 1.5% to 2.5% relative to the diameter of the connection end portion obtained from the step of primary cold-working.

In accordance to an embodiment of the present invention, the step of roll-threading such that the diameter of the thread as measured from one crest to another crest disposed in symmetrical opposition along a circumferential surface of the connection end portion of the reinforcing bar, is larger than the nominal diameter of the reinforcing bar, is a step in which diameter of the thread is larger by 15% to 35%.

It is an advantage of the present invention to provide a method for working a thread onto a connection end portion of a reinforcing bar for reinforcing concrete which eliminates the need for hot-working and therefore eliminates the additional cost associated with hot-working.

It is another advantage of the present invention to provide a method for working a thread onto a connection end portion of a reinforcing bar for reinforcing concrete which eliminates the need for material removal from said reinforcing bar.

It is also another advantage of the present invention to provide a method for working a thread onto a connection end portion of a reinforcing bar for reinforcing concrete which mitigates non-uniformity of material structure throughout the reinforcing bar despite being cold-worked.

It is another advantage of the present invention to provide a method for working a thread on to a connection end portion of a reinforcing bar for reinforcing concrete that produces a high quality and consistent thread while also preferably reducing construction costs.

The present invention and/or forms thereof maintain the material in the reinforcing bar to form a suitable surface for forming threads thereon. This accordingly maintains the strength in the bar. Squeezing the bar to reduce its diameter, results in a more consistent and even round shape than in other methods.

5 Moreover, the method for working a thread onto a connection end portion of a reinforcing bar as provided by the present invention mitigates non-uniformity of material structure throughout the reinforcing bar despite being cold-worked. Specifically, the method of the present invention mitigates the incidence of work-piece hardening which results in high tensile strength and hardness and a decrease

10 in impact absorption energy due to said work-piece hardening, by providing a gradual increase in the diameter of the connection end portion of the reinforcing bar, from a step of primary cold-working to effect axial upsetting to the final step of roll-threading.

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BRIEF DESCRIPTION OF THE DRAWINGS

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The above and other objects, features and other advantages of the present invention will be more clearly understood from the detailed description taken in conjunction with the accompanying drawings, in which:

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Figure 1 is a flow-chart illustrating steps entailed in a method for working a thread on a connection end portion of a reinforcing bar, according to an embodiment of the present invention;

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Figure 2 is a diagram illustrating a partial view of a reinforcing bar of the type disposed with ribs and fins for use in reinforcing concrete, according to the present invention;

Figures 3 to 6 are diagrams illustrating the various stages of a method for working a thread on a connection end portion of a reinforcing bar, such as the reinforcing bar shown in Figure 2, according to an embodiment of the present invention;

Figure 7 is schematic drawing showing a partial view of a reinforcing bar and its connection end portion which has been worked in accordance to an embodiment of

the present invention and which is directed at illustrating the changes in diameter of the connection end portion as it is worked through the various stages of the method according to an embodiment of the present invention; and

- 5 Figure 8 is a table detailing various machine die parameters for cold-forging, cold-squeezing, roll threading and the changes in dimensions of the diameter of the connection end portion of an exemplary type of reinforcing bars having differing sizes, when the connection end portion of the reinforcing bars are subjected to the various stages of the method in accordance to an embodiment of the present
10 invention; and

Figures 9 and 10 are diagrams illustrating interconnection of two reinforcing bars having connection end portions similarly worked with threads in accordance to an embodiment of the method of the present invention utilizing a mechanical sleeve
15 coupler disposed with threads complimentary to the threads of said connection end portions at an inner circumferential surface.

DETAILED DESCRIPTION OF THE INVENTION

- 20 The detailed description set forth below in connection with the appended drawings is intended as a description of an exemplary embodiment and is not intended to represent the only form in which the embodiment may be constructed and/or utilized. The description sets forth the functions and the sequence for constructing the exemplary embodiment. However, it is to be understood that the same or
25 equivalent functions and sequences may be accomplished by different embodiments that are also intended to be encompassed within the scope of this disclosure.

The method, in accordance to embodiments of the present invention will now be
30 described in conjunction with Figures 1 to 10 appended herewith. Making reference to Figure 1, before proceeding with a detailed description of the method **200** for working a connection end portion **40** of a reinforcing bar **100**, in accordance to embodiments of the present invention, it should be noted that the method **200** of the present invention is directed toward the working of a thread **90** on a connection end

portion **40** of a reinforcing bar **100** of the type disposed with a plurality of ribs **10** and fins **20**. The connection end portion **40** of the reinforcing bar **100** is defined as a terminal portion disposed with an end face **50**, of a given longitudinally extending reinforcing bar **100**, which is designated for interconnection with another
5 longitudinally extending reinforcing bar **100**, such that the reinforcing bars **100** are interconnected end-end in spatial symmetrical opposition. Further, the term nominal diameter as mentioned throughout the description refers to the diameter of the reinforcing bar **100** that does not take into consideration the dimensions of the ribs **10** and fins **20** disposed along the reinforcing bar **100**, and is the diameter of the
10 reinforcing bar **100** as is, prior to being subjected to any working or machining. This diameter is denoted with the alphabet 'D' throughout the Figures appended herewith.

With reference to Figures 1 and 2, the present invention provides a method **200** for
15 working a thread **90** on a connection end portion **40** of a reinforcing bar **100** having ribs **10** and fins **20** for reinforcing concrete which allows a formation of a joint by splicing two reinforcing bars **100** end to end via a mechanical sleeve coupler **150** having a thread **160** at an inner circumferential surface **170**, each reinforcing bar **100** having a connection end portion **40** that has been threaded with a thread **90**
20 complimentary to the thread **160** disposed at the inner circumferential surface **170** of the mechanical sleeve coupler **150**; wherein the method **200** comprises:

a step **201** of facing and chamfering an end face **50** of the connection end portion **40** to remove surface irregularities present on the end face **50** and thereby
25 provide a connection end portion **40** with a substantially smooth and level end face **50**;

a step **202** of primary cold-working to effect axial upsetting of the connection end portion **40** of the reinforcing bar **100**, such that a diameter of the connection end portion **40** of the reinforcing bar **100** is increased relative to the nominal diameter **D** of the reinforcing bar **100**;

a step **203** of secondary cold-working the connection end portion **40** obtained from the step **202** of primary cold-working, such that the diameter of the

connection end portion **40** of the reinforcing bar **100** is decreased relative to its diameter after primary cold-working to effectively flatten protuberances due to the ribs **10** and fins **20** of the reinforcing bar **100** at the connection end portion **40**; and

5 a step **204** of roll-threading to form a thread **90** on the connection end portion **40** of the reinforcing bar **100**, such that the diameter of the thread **90** as measured from one crest **90a** to another crest **90a** disposed in symmetrical opposition along a circumferential surface of the connection end portion **40**, is larger than the nominal diameter **D** of the reinforcing bar **100**.

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In accordance to a preferred embodiment not specifically alluded to the in the list of figures appended herewith, the method **200** further includes a preliminary step of cutting the reinforcing bar **100**, to re-sect a terminal cylindrical portion of the reinforcing bar **100** to thus obtain a connection end portion **40** which has a substantially level end face **50**. In accordance to embodiments of the method **200** of the present invention, the preliminary step of cutting the reinforcing bar **100** is executed by way of a rebar cutting machine utilizing a cutting blade. In accordance to yet other embodiments of the method **200** of the present invention, aforementioned preliminary step **201** of cutting the reinforcing bar **100** is executed by a tool selected from a list including any one of a circular saw, band saw, rebar cutter or a chop saw.

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With reference to Figures 1 and Figures 3 through 7, the various remaining steps **201** to **204** of the method **200** of the present invention will be elaborated on.

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Making reference to Figure 1 and Figure 3, a step **201** of facing and chamfering is executed to effect removal of surface irregularities such as burrs on the end face **50** of the connection end portion **40** of the reinforcing bar **100** and thereby provide a substantially smooth and defect free end face **50**. More particularly, facing or milling the end face **50** of the connection end portion **40**, serves to remove any surface irregularities present thereon and chamfering or bevelling the edges of the end face **50** of said connection end portion **40** serves to prevent destruction of a thread formed on the connection end portion **40** in a subsequent step of the method **200** in accordance to embodiments of the present invention.

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Next, in step **202**, primary cold-working is executed to effect axial upsetting of the connection end portion **40** of the reinforcing bar **100**, such that a diameter of the connection end portion **40** of the reinforcing bar **100** is increased relative to the nominal diameter **D** of the reinforcing bar **100**. The resulting increased diameter of the connection end portion **40** is denoted as **D2** in Figures 4 and 7 appended herewith. In accordance to an embodiment, aforementioned step **202** of primary cold-working is a step of cold-forging executed by way of a cold-forging die. More particularly, in accordance to a preferred embodiment of the method **200**, primary cold-working takes on the form of impact cold-forging and is executed by way of an impact forging die. More particularly, in this step **202** in accordance to an embodiment of the method **200**, a portion of the reinforcing bar **100** is secured and the outwardly projecting connection end portion **40** is held in position between dies of a cold-forging machine with said connection end portion **40** being cold-worked once the dies are actuated. With reference to aforementioned Figure 4, upon actuation of the dies (denoted as **M2** in Figure 4), the metal is worked/formed so as to conform to the dimensions of the die, thus increasing the diameter of the connection end portion **40** from **D** to **D2** by a predetermined amount, such that the new diameter **D2** of the connection end portion **40** conforms to dimensions of a cavity formed by the actuation/closing of the dies.

It should be readily understood by one of ordinary skill in the art, that cold working alludes to the process of strengthening metals through plastic deformation. This is made possible through the dislocation movements that are produced within a material's crystal structure. Moreover, it would be readily understood by one of ordinary skill in the art, that cold-working is a steel or metal working process in which metal or steel is shaped below its re-crystallization temperature. Even yet further, one of ordinary skill in the art would understand that cold working causes the crystal grains and inclusions to distort following the flow of the metal; which may cause work hardening and anisotropic material properties and work hardening makes the metal harder, stiffer, and stronger, but less plastic.

In accordance to a preferred embodiment of the method **200** of the present invention, the step **202** of primary cold-working to effect axial upsetting of the

connection end portion **40** of the reinforcing bar **100** such that the diameter of the connection end portion **40** of the reinforcing bar **100** is increased, is a step in which the diameter of the connection end portion **40** of the reinforcing bar **100** is increased by a small fraction, relative to the nominal diameter **D** of the reinforcing bar **100** prior to said step **202** of primary cold working. Preferably, in said step **202** of primary cold-working, the diameter of the connection end portion **40** of the reinforcing bar **100** is increased by 10% to 25%, relative to the nominal diameter of the reinforcing bar **100** prior to said step of primary cold working **202**.

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Moving on with the description of the method **200** of the present invention in accordance to an embodiment, a step **203** of secondary cold-working the connection end portion **40** obtained from the step **202** of primary cold-working is executed, such that the diameter of the connection end portion **40** of the reinforcing bar **100** is decreased relative to its diameter after primary cold-working to effectively flatten protuberances due to the ribs **10** and fins **20** of the reinforcing bar **100** at the connection end portion **40**. The resulting decreased diameter of the connection end portion **40** is denoted as **D4** in Figures 5 and 7 appended herewith. In accordance to an embodiment of the present invention, the step **203** of secondary cold working is a step of cold squeezing executed by a cold-squeezing die (denoted as **M3** in Figure 5), to effectively flatten protuberances due to the ribs **10** and fins **20** of the reinforcing bar **100**.

In accordance to a preferred embodiment of the present invention, the step **203** of secondary cold working, is a step of extruding the connection end portion obtained from the step **202** of primary cold working such that the diameter of the connection end portion **40** of the reinforcing bar **100** is decreased by a minute fraction of its diameter after primary cold working to effectively flatten protuberances due to the ribs **10** and fins **20** of the reinforcing bar **100** at the connection end portion **40**. Preferably, in said step **203** of secondary cold-working, the diameter of the connection end portion **40** of the reinforcing bar **100** is decreased by 1.5% to 2.5% relative to the diameter of the connection end portion **40** of the reinforcing bar **100** obtained from the step **202** of primary cold-working. In accordance to said preferred embodiment of the present invention, the step of extruding the connection end

portion **40** of the reinforcing bar **100** comprises urging said connection end portion **40** through a squeezing die of a squeezing machine. Such a squeezing machine having a squeezing die is well known to persons of ordinary skill in the art. In accordance to said preferred embodiment of the method **200** of the present invention, the connection end portion **40** of the reinforcing bar **100** that results from step **202** of primary cold-working, is in step **203** of secondary cold working, extruded through a squeezing die of a squeezing machine having a substantially conical-funnel opening, in which a first terminal portion of the opening has a diameter larger than the diameter of the connection end portion **40** of the reinforcing bar **100** that results from aforementioned step **203**, while the opening is narrowest at a second terminal portion. The diameter of the opening at the second terminal portion is about equal to the diameter of the resulting extruded/squeezed connection end portion **40** of the reinforcing bar **100**. In other words, the diameter of the second terminal portion of the substantially conical-funnel opening is configured to be equal to a desired diameter, which in accordance to the embodiment of the method **200** of the present invention, is preferably smaller by 1.5% to 2.5% of the diameter of the connection end portion **40** of the reinforcing bar **100** that results from the step **202** of primary cold-working. It should be noted that aforementioned squeezing die, is exemplarily formed of tool steel which exhibits a hardness of 65 and 75 on the Rockwell scale.

The final step **204** of the method **200** in accordance to an embodiment of the present invention, is a step **204** of roll threading to form a thread **90** on the connection end portion **40** of the reinforcing bar **100**, such that the diameter of the thread **90** as measured from one crest **90a** to another crest **90a** disposed in symmetrical opposition along a circumferential surface of the connection end portion **40**, is larger than the nominal diameter **D** of the reinforcing bar **100**. The resulting diameter of the thread **90** formed on the connection end portion **40** of the reinforcing bar **100** as measured from one crest **90a** to another crest **90a** disposed in symmetrical opposition along a circumferential surface of the threaded connection end portion **40** is denoted as **D6** in Figures 6 and 7 appended herewith. In accordance to an embodiment of the method **200**, the step **204** of roll-threading such that the diameter of the thread **90** as measured from one crest **90a** to another crest **90a** disposed in symmetrical opposition along a circumferential surface of the

connection end portion **40** of the reinforcing bar **100**, is larger by a fraction of the nominal diameter of the reinforcing bar **100**, preferably larger by about 15% to 35% than the nominal diameter **D** of the reinforcing bar **100**.

5 It would be understood by one of ordinary skill in the art, that roll threading is an external threading process that shapes a given feed-stock (in our case the connection end portion **40** that results from the step **203** of secondary cold-working) by passing it through roller dies of a roll threading machine (schematically depicted as **M4** in Figure 6). The roller dies have external thread-like rollers which contact
 10 and deform the surface of the feed-stock. The advantages of roll threading include high thread strength of the resulting thread formed on a given feedstock, the resulting thread has a low mechanical tolerance (thread is machined with high accuracy and precision), and good surface finish, among others. In accordance to a preferred embodiment of the method **200** of the present invention, the final step
 15 **204** of roll-threading, is a step of roll-threading to form a substantially circular thread on a connection end portion **40** of a reinforcing bar **100**, in which the pitch and flank angles are small. Such a thread **90** formed on the connection end portion **40** of the reinforcing bar **100**, would be desirable as such a thread **90** would promote secure fastening and mitigate the incidence of relaxation even in the presence of
 20 considerable vibration.

Figure 8 provides a table detailing various machine die parameters for cold-forging, cold-squeezing, roll threading and the changes in dimensions of the diameter of the connection end portion **40** of an exemplary type (i.e. 'H-High Tensile Steel') of
 25 reinforcing bars **100** having differing sizes, when the connection end portion **40** of the reinforcing bars **100** are subjected to the various steps **201** to **204** of the method **200** in accordance to an embodiment of the present invention. The table in Figure 8 should be read in conjunction with Figure 7. More particularly, with reference to the table of Figure 8 and the schematic diagram of a reinforcing bar
 30 **100** of Figure 7, there is shown the changes in dimensions of the diameter of the connection end portion **40** of various sizes of type H reinforcing bars **100**, i.e. reinforcing bars **100** having sizes H13 to H50. It is observed from the table (see column in table which is labelled as " $(D_2-D)/D \times 100$ ", that the diameter of the connection end portion **40** of the reinforcing bars **100** after a step **202** of primary

cold-working (which in accordance to an embodiment is a step of cold forging) is increased to roughly within the range of 10% to 25% of the nominal diameter **D** of the reinforcing bars **100** (i.e. increase of 10% to 25% in diameter from **D** to **D2** results after cold-forging). Likewise, it is observed from the table (see column in table which is labelled as “ $(D4-D2)/D2 \times 100$ ”) that the diameter **D4** of the connection end portion **40** of the reinforcing bars **100** after a step **203** of secondary cold-working (which in accordance to an embodiment is a step of cold-squeezing) is decreased within a range of 1.5% to 2.5% of the diameter **D2** of the connection end portion **40** that results from the step of cold-forging. Finally, it is observed from the table (see column in table which is labelled as “ $(D6-D)/D \times 100$ ”) that the diameter **D6** which refers to the outer diameter of the thread formed by the final step **204** of roll-threading the connection end portion **40** of the reinforcing bars **100**, is increased within the range of 15% to 35% of the nominal diameter **D** of the reinforcing bars **100**.

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With reference to Figures 9 and 10 once the step **204** of roll-threading has been completed and the final thread **90** has been formed on the connection end portion **40** of the reinforcing bar **100**, the reinforcing bar **100** is ready for use. Specifically, in use, two reinforcing bars **100** with connection end portions **40** disposed with thread **90** worked on said connection end portions **40** in accordance to a method **200** of the present invention, may be connected to one another in an end-to-end fashion by way of a mechanical sleeve coupler **150**. Each threaded connection end portion **40** of aforesaid reinforcing bars **100** may be connected to one another by screwing the respective connection end portions **40** at the symmetrically opposing threaded openings of the mechanical sleeve coupler **150**. This is possible in view of the fact the mechanical sleeve coupler **150** is disposed at an inner circumferential surface **170** projecting inwardly from the symmetrically opposed openings with thread formations **160** and pitch profiles that are complimentary to the threads **90** of the connection end portions **40** of the respective reinforcing bars **100**, thus enabling the secure and snug mating of the reinforcing bars **100** in an end-to-end configuration via aforesaid mechanical sleeve coupler **150**. A continuous joint **300** is then produced for use in reinforcing concrete, for example in the building construction industry.

CLAIMS

1. A method (200) for working a thread (90) on a connection end portion (40) of a reinforcing bar (100) having ribs (10) and fins (20) for reinforcing concrete
5 which allows a formation of a joint by splicing two reinforcing bars (100) end to end via a mechanical sleeve coupler (150) having a thread (160) at an inner circumferential surface (170), each reinforcing bar (100) having a connection end portion (40) that has been threaded with a thread (90) complimentary to the thread (160) disposed at the inner circumferential surface (170) of the mechanical sleeve
10 coupler (150); wherein the method (200) comprises:

a step (201) of facing and chamfering an end face (50) of the connection end portion (40) to remove surface irregularities present on the end face (50) and thereby provide a connection end portion (40) with a substantially smooth and level
15 end face (50);

a step (202) of primary cold-working to effect axial upsetting of the connection end portion (40) of the reinforcing bar (100), such that a diameter of the connection end portion (40) of the reinforcing bar (100) is increased relative to the
20 nominal diameter D of the reinforcing bar (100);

a step (203) of secondary cold-working the connection end portion (40) obtained from the step (202) of primary cold-working, such that the diameter of the connection end portion (40) of the reinforcing bar (100) is decreased relative to its
25 diameter after primary cold-working to effectively flatten protuberances due to the ribs (10) and fins (20) of the reinforcing bar (100) at the connection end portion (40); and

a step (204) of roll-threading to form a thread (90) on the connection end
30 portion (40) of the reinforcing bar (100), such that the diameter of the thread (90) as measured from one crest (90a) to another crest (90a) disposed in symmetrical opposition along a circumferential surface of the connection end portion (40), is larger than the nominal diameter 'D' of the reinforcing bar (100).

2. The method (200) according to claim 1, wherein the step (202) of primary cold working is a step of cold-forging executed by way of a cold forging die.
3. The method (200) according to claim 1, wherein the step (203) of secondary cold working is a step of cold-squeezing executed by way of a cold-squeezing die.
4. The method (200) according to claim 1, wherein the step (203) of secondary cold-working is a step of extruding the connection end portion (40) of the reinforcing bar (100) obtained from the step (202) of primary cold working.
5. The method (200) according to claim 1, wherein the step (202) of primary cold-working to effect axial upsetting of the connection end portion (40) of the reinforcing bar (100) is a step in which the diameter of the connection end portion (40) of the reinforcing bar (100) is increased by 10% to 25% relative to the nominal diameter 'D' of the reinforcing bar (100).
6. The method (200) according to claim 1, wherein the step (203) of secondary cold-working is a step in which the diameter of the connection end portion (40) of the reinforcing bar (100) is decreased by 1.5% to 2.5% relative to the diameter of the connection end portion (40) after the step (202) of primary cold-working.
7. The method (200) according to claim 1, wherein the step (204) of roll-threading is a step in which the diameter of the thread (90) on the connection end portion (40) of the reinforcing bar (100) as measured from one crest (90a) to another crest (90a) disposed in symmetrical opposition along a circumferential surface of the connection end portion (40), is larger than the nominal diameter 'D' of the reinforcing bar (100), by 15% to 35%.