ABSTRACT

A method of forming anchors at the ends of rebars includes providing an anchor plate, forming an opening through the anchor plate that is larger than the diameter of the rebar, heating the end of a rebar, inserting it into the anchor plate opening and then forging it to upsize the rebar end into engagement with the wall of the anchor plate opening. Preferably, the wall of the opening through the anchor plate is irregular to enhance the interlock between the up sized rebar end and the anchor plate. The resulting rebar end anchor then finds particular utility in reinforced concrete structure at joint intersections of for example, a beam and column or wall.
REINFORCED CONCRETE STRUCTURE, REBAR END ANCHOR THEREFOR AND METHOD OF MANUFACTURING

FIELD OF THE INVENTION

Background of the Invention

[0001] Concrete is characterized by high compressive strength and notoriously poor tensile strength. In a typical reinforced concrete structure this deficiency in the tensile strength of the concrete is obviated by imbedding in the concrete at those points where tensile stress will be encountered, reinforcing bars, typically of steel. Where a section of a reinforced concrete structure terminates at another section, such as at a beam/wall or beam/column intersection, provision must also be made to insure that the ends of the rebars will not pull out of the wall or column when tensile stress is encountered. Conventionally, this was remedied by bending the end of the rebar and perhaps inserting another rebar beneath the bend perpendicularly to the length of the first rebar. Typically, a joint of this type is congested to begin with and this remedy compounded the congestion, resulting in higher concrete placement costs and possible concrete consolidation problems.

[0002] To avoid these problems it is known to provide an enlarged head at the rebar end, either through forging or by welding a plate on the rebar end, or providing a plate with a threaded opening, upsetting the end of the rebar to enlarge its diameter and then threading the enlarged end complementarily to the anchor plate threaded opening and screwing the plate onto the threaded rebar end.

[0003] Where the rebar ends are provided with a forged head, a very large forging press is required, a substantial portion of the rebar must be preheated for forging with a commensurate expenditure of time and energy, and multiple strikes of the press are required to create the headed end. Where the end plate is a separate part with a threaded opening receiving a threaded end of the rebar, the rebar end must first be upsized through a forging process before the threads are cut into the rebar end. This is necessary to achieve the ultimate strength of the rebar. If the rebar were threaded without upsizing the end, the thread would create a weak point that would reduce the overall tensile strength of the rebar.

[0004] As noted above, it is also known to weld an anchor plate to the end of a rebar, typically through an inertia welding process. This approach has the drawbacks of requiring a separate fabricated anchor plate and requiring the upsizing of the rebar end prior to welding, but more importantly, the welding process is subject to various process variables that contribute to quality considerations.

[0005] It will be seen, therefore, that a need exists for a rebar anchorage to reduce congestion at a joint intersection in a reinforced concrete structure, but without the disadvantages noted above with respect to conventional methods of providing an end anchorage for concrete reinforcing bars.

SUMMARY OF THE INVENTION

[0006] The present invention provides a method of manufacturing an end anchor of superior structural performance but with the expenditure of less energy required than in comparable prior art methods, resulting in cost savings and a unique end anchor product.

[0007] Specifically, in accordance with the present invention a separate anchor plate is provided, which may be round, square, rectangular or other configuration and through the plate an opening having irregular wall portions is formed. Conventional rebar having an effective outer diameter smaller than the size of the opening through the anchor plate is preheated at its end, the heated end inserted into the opening through the plate and then forged onto the plate by upsizing the rebar end and filling the hole through the plate with rebar material to form a mechanical interlock with the irregular wall portions of the opening through the anchor plate.

[0008] This method permits the use of smaller forging presses than would be required to forge the end of a rebar into an end anchor and requires less heat prior to forging and less strikes of the forging press to complete the assembly. Thus, an end anchor in accordance with the present invention may be produced in less time and with less energy than comparable processes for forming rebar end anchors.

[0009] As a result, the construction of an intersecting joint, such as the termination of a beam into a column or wall in a reinforced concrete structure is greatly facilitated, while conserving the energy and commensurate expense thereof usually associated with end anchors of this type. Therefore, in a typical intersection of this type, where reinforcing bars and associated ties create a congested condition, the necessity of contributing to that congestion by bending the end of the terminating rebar and providing cross rebar members within the bend is avoided but again, without the expense attended to conventional end anchors.

[0010] Additionally, the process of forging the rebar into the anchor plate provides the added benefit of upsizing the rebar at the connection. This provides a stronger section of rebar at the connection and ensures that the rebar, if subjected to ultimate tensile stress, will break at a location distant from the anchor plate connection. This is an important feature because there are standards that require failure to occur away from the connection. This makes it obvious that the rebar has failed and not the anchor plate-rebar connection.

[0011] These and other objects and advantages of the present invention will become apparent from the following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with a general description of the invention given above, and the detailed description of the embodiments given below, serve to explain the principles of the invention.

[0013] FIG. 1 is a perspective view showing a typical beam-column connection utilizing one embodiment of end anchors in accordance with the present invention;

[0014] FIG. 2 is a perspective view of an end anchor plate in accordance with the present invention illustrating an opening through the plate having one form of irregularly shaped walls, in this embodiment, taking the form of internal grooves,
FIG. 3 is an elevational view, partly in section, showing an end of a conventional rebar about to be received in an opening through the anchor plate of FIG. 2.

FIG. 4 is a view similar to FIG. 3, but illustrating the rebar end after it has been preheated and forged into mechanical interlock with the irregularly shaped walls of the opening through the anchor plate of FIG. 3.

FIG. 5 is a view similar to FIG. 3, but showing a second embodiment of the invention, wherein the irregularly shaped wall portions of the opening through the anchor plate are formed as a counterbore.

FIG. 6 illustrates the end of a rebar received in the opening of the anchor plate shown in FIG. 5 after the rebar has been preheated and forged into interlocking engagement with the irregular walls of the anchor plate.

FIG. 7 is an end view of the anchor plate and forged in place rebar of FIG. 4.

FIG. 8 is a view similar to FIG. 7 but illustrating another embodiment of the present invention, wherein the anchor plate is formed with a square configuration.

FIG. 9 is a view similar to FIG. 8, but wherein the anchor plate is rectangular, and

FIG. 10 is a perspective view of another embodiment of anchor plate showing another form of irregularity in the side walls of the opening through the anchor plate designed to be mechanically interlocked with the heated, forged end of a rebar.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 of the drawings depicts a beam-column connection 10, which comprises a column 12, a through beam, consisting of beam segments 14 and 16 and a beam 18 terminating at the connection. As will be apparent from FIG. 1, the intersecting vertical reinforcing bars, as at 20 and the horizontal intersecting bars, as at 22 and their associated ties, as at 24, create a congestion which, in conventional connections of this type is exacerbated by the addition of the rebars projecting from the terminating beam, particularly where the rebars of the terminating beam are bent at substantially right angles and additional rebar inserted in the bend to resist withdrawal. A disadvantage of this increased congestion is poor concrete consolidation, higher concrete placement costs and poor in place concrete quality. This condition is ameliorated in accordance with the present invention by providing rebar 26 with anchor ends comprising anchor plates, one embodiment of which is shown at 30 and which are attached to the rebar in a method in accordance with the present invention. While the plates 30 shown in FIG. 1 are rectangular, it will be apparent as the description proceeds that the plates may assume other configurations, such as circular and square.

Thus, as seen in FIG. 2 of the drawings, an anchor plate 32 of round or circular configuration is shown having an opening 34 formed there through. As will be apparent from FIG. 2, the wall portions of the opening 34 are irregular, that is, the wall portion of the opening 34 is not merely a smooth constant diameter surface extending through the anchor plate 32. Instead, the wall portions of the opening 34 are, in the embodiment of FIG. 2, provided with circular grooves 36. While the grooves 36 of FIG. 2 comprise a threaded opening, as may also be seen in FIGS. 3 and 4, it will be apparent the grooves 36 may also be simply a series of parallel circular grooves.

In any case, it will be noted from FIG. 3 of the drawings that the outer surface of rebar 37 is provided with deformations 38 which enhance its embedment in the concrete beam 18. While the rebars 20, 22 and 26 are shown as smooth surfaced in FIG. 1 of the drawings, in actuality all of the bars would preferably be provided with deformations such as at 38 as shown in FIG. 3 of the drawings. It will also be noted from FIG. 3 that the nominal outer diameter of the rebar 37 is smaller than the opening 34 through the plate 32. This permits the anchor end 40 of the rebar to be inserted freely into the opening 34.

However, prior to placing the anchor end 40 of the rebar 37 into the opening 34, end 40 is first heated and then, after it is received in the opening, subjected to an axial force and thus forged into place in mechanical interlocking relationship with the irregular wall portions 36 of the anchor plate 32. In other words, the heated end 40 of the rebar 37 is upsized by forging, filling in the irregularities 36 in the opening 34 through the anchor plate 32 with material from the rebar to form a mechanical joint. As noted above, upsizing the rebar ensures that it encounters ultimate tensile stress, it will break at a point remote from the joint with the anchor plate.

While the end anchor construction shown in FIG. 4 of the drawings is formed by forging the heated, anchor end 40 of the rebar 26 into the grooves 36, it is possible to utilize other wall irregularities as depicted in FIG. 5 of the drawings. Here, anchor plate 42 is provided with a counterbored opening 44 having a first portion 46 a second portion 48 and an interconnecting portion 50. Otherwise, the process of manufacturing the rebar anchor end of FIG. 5 proceeds similarly to that previously described. Thus, anchor end 52 of rebar 54 is first heated and then, because the nominal diameter of the rebar 54 is smaller than the first portion 46 of the opening 44 through the plate 42, it is freely received in the opening 44, after which the heated anchor end 52 is forged to expand outwardly and fill the entire area of the counterbored opening 44, including, not only the smaller diameter portion 46, but also the counterbored portion 48 and the interconnecting portion 50. Thus, again the heated anchor end of the rebar is upsized to fill the opening 44 and form a mechanical joint between the rebar and the anchor plate 42.

FIG. 10 of the drawings shows yet another embodiment of anchor plate 60 having an opening 62 there through having irregular wall portions 64. In the embodiment of FIG. 10 the irregular wall portions 64 take the form of alternating peaks 66 and valleys 68 extending about the entire wall portion of the opening 62. While not specifically shown, it will be apparent that a mechanical interlock connection is made between the irregularly configured wall portions 64 of the anchor plate 60 in the same manner as the embodiments of FIGS. 4 and 6. That is, a rebar having a nominal diameter smaller than the opening 62 is first heated and then inserted into the opening 62 where it is forged, thereby upsizing the heated end of the rebar and filling all of the spaces around the alternating peaks 66 and valleys 68 to create a mechanical interlock between the rebar and the anchor plate 60.
While in the embodiment of FIG. 4 of the drawings, the anchor plate 32 is shown as round, the anchor plate may take various other configurations, including a polygonal shape and more specifically, a rectangular shape as shown at 35 in FIG. 9 of the drawings or a square shape as shown at 33 in FIG. 8 of the drawings. It will also be apparent that the anchor plates 42 and 60 may also assume round, polygonal, rectangular and square shapes, similarly to the embodiment of FIG. 4 of the drawings.

Regardless of the specific configuration of the anchor plate it will be apparent that the present invention provides a method of fastening securely an anchor plate to an standard rebar by forming an irregularly shaped wall portion defining an opening through the anchor plate, heating an end of the rebar, inserting it into the opening in the anchor plate and then forging the heated end of the rebar to upsize it and fill the interstices provided by the irregular wall portions of the opening through the anchor plate, resulting in a secure mechanical interlock between the end of the rebar and the anchor plate. Thus, the advantages of utilizing an end anchor in place of merely bending the terminal portion of a rebar and inserting a crossing rebar are obtained, but without the expenditure of energy and expense associated with end anchors of this type. While the methods and structures formed thereby described herein constitute preferred embodiments of the invention it is to be understood that the invention is not limited to these precise forms of method and structure formed thereby and that changes may be made therein without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. A rebar anchor comprising:
an anchor plate,
an opening formed through said anchor plate,
said opening having irregular wall portions,
a rebar having an anchor end and an outer surface and deformations formed in said outer surface,
said rebar anchor end being received in said anchor plate opening and forged into mechanical interlock with said irregular wall portions of said opening.

2. The combination of claim 1 wherein said rebar is of substantially constant diameter prior to being forged into mechanical interlock with said irregular wall portions of said opening through said anchor plate.

3. The combination of claim 2 wherein said rebar diameter is smaller than said opening through said anchor plate.

4. The combination of claim 3 wherein said irregular wall portions comprise circular grooves.

5. The combination of claim 4 wherein said grooves comprise threads.

6. The combination of claim 3 wherein said irregular wall portions comprise a counterbore formed in said opening in said anchor plate.

7. The combination of claim 3 wherein said irregular wall portion comprise alternating peaks and valleys projecting inwardly in said opening.

8. The combination of claim 1 wherein said anchor plate is substantially round.

9. The combination of claim 1 wherein said anchor plate is polygonal.

10. The combination of claim 1 wherein said anchor plate is rectangular.

11. A reinforced concrete structure comprising:
a concrete body;
a concrete beam intersecting said body,
a reinforcing bar imbedded in said body and said beam and having an end terminating in said body, an end anchor plate,
an opening formed through said anchor plate,
said opening having irregular wall portions, and said end of said reinforcing bar being received in said opening and forged into mechanical interlock with said irregular wall portions of said opening.

12. The structure of claim 11 wherein said reinforcing bar is substantially constant in diameter prior to being forged into mechanical interlock with said irregular wall portions of said opening through said anchor plate.

13. The structure of claim 12 wherein said reinforcing bar diameter is smaller than said opening through said anchor plate.

14. The structure of claim 13 wherein said irregular wall portions comprise circular grooves.

15. The structure of claim 14 wherein said grooves comprise threads.

16. The structure of claim 13 wherein said irregular wall portions comprise a counterbore formed in said opening through said anchor plate.

17. The structure of claim 13 wherein said irregular wall portions comprise alternating peaks and valleys projecting into said opening in said anchor plate.

18. The structure of claim 11 wherein said anchor plate is substantially round.

19. The structure of claim 11 wherein said anchor plate is polygonal.

20. The structure of claim 19 wherein said anchor plate is substantially rectangular.

21. A method of manufacturing a rebar with end anchor comprising:
providing an anchor plate,
forming an opening through said anchor plate having irregular wall portions,
providing a length of rebar having an anchor end,
heating said anchor end of said rebar,
inserting said heated anchor end of said rebar into said opening in said anchor plate, and
forging said heated anchor end of said rebar into mechanical interlock with said irregular wall portions of said opening in said anchor plate.

22. The method of claim 21 wherein said rebar is of substantially constant diameter prior to being forged into mechanical interlock with said irregular wall portions of said anchor plate.

23. The method of claim 22 wherein said substantially constant diameter of said rebar is smaller than said opening through said anchor plate.

24. The method of claim 23 wherein said irregular wall portions comprise circular grooves.
25. The method of claim 24 wherein said circular grooves comprise threads.

26. The method of claim 23 wherein said irregular wall portions comprise a counterbore formed in said opening through said anchor plate.

27. The method of claim 23 wherein said irregular wall portions comprise alternating peaks and valleys projecting into said opening in said anchor plate.

28. The method of claim 21 wherein said anchor plate is substantially round.

29. The method of claim 21 wherein said anchor plate is substantially polygonal.

30. The method of claim 29 wherein said anchor plate is substantially rectangular.

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