contacting the second sub-surface of the groove with another portion of the arcuate projection.

The invention also encompasses a method of using a coupling having an arcuate projection engaged with a groove of a pipe element. In one example the method comprises:

applying a tensile force between the pipe element and the coupling, thereby causing a portion of the arcuate projection to engage the first sub-surface and another portion of the arcuate projection to engage the third sub-surface.

In view of the above, in accordance with a first aspect of the present disclosure, there is provided, in combination, a pipe element having first and second oppositely disposed ends and a coupling, said pipe element comprising:

a sidewall surrounding a longitudinal axis and defining a bore, said sidewall having an outer surface;

a first groove positioned in said outer surface, said first groove extending circumferentially around said bore and positioned proximate to said first end, said first groove being defined by a first plurality of sub-surfaces of said outer surface including:

a first sub-surface oriented at an angle with respect to said longitudinal axis and facing away from said first end;

a second sub-surface oriented at an angle with respect to said longitudinal axis, said second sub-surface being in spaced relation away from and facing toward said first sub-surface;

a third sub-surface contiguous with said first sub-surface, said third sub-surface oriented at an angle with respect to said longitudinal axis and sloping toward said second sub-surface; and

a fourth sub-surface contiguous with said third and second sub surfaces, said fourth sub-surface being oriented at an angle with respect to said longitudinal axis;

said coupling comprising:

a plurality of segments attached to one another end to end surrounding said first end of said pipe element;

adjustable attachment members positioned at each end of said segments for attaching said segments to one another;

at least one arcuate projection positioned on one side of each of said segments and engaged with said first groove, said at least one arcuate projection comprising a plurality of mating surfaces including:

a first mating surface oriented at an angle with respect to said longitudinal axis and in facing relation with said first sub-surface;

a second mating surface oriented at an angle with respect to said longitudinal axis and in facing relation with said second sub-surface;

a third mating surface oriented at an angle with respect to said longitudinal axis and contacting said third sub-surface; and

a fourth mating surface in facing relation with said fourth sub-surface; wherein

said at least one arcuate projection comprises a recess therein forming a gap between fourth mating surface and said fourth sub-surface.

In accordance with a second aspect of the present disclosure, there is provided, in combination, a pipe element having first and second oppositely disposed ends and a coupling, said pipe element comprising:

a sidewall surrounding a longitudinal axis and defining a bore, said sidewall having an outer surface;

a first groove positioned in said outer surface, said first groove extending circumferentially around said bore and positioned proximate to said first end, said first groove being defined by a first plurality of sub-surfaces of said outer surface including:

a first sub-surface oriented at an angle with respect to said longitudinal axis and facing away from said first end;

a second sub-surface oriented at an angle with respect to said longitudinal axis, said second sub-surface being in spaced relation away from and facing toward said first sub-surface;

a third sub-surface contiguous with said first sub-surface, said third sub-surface oriented at an angle with respect to said longitudinal axis and sloping toward said second sub-surface; and

a fourth sub-surface contiguous with said third and second sub surfaces, said fourth sub-surface being oriented at an angle with respect to said longitudinal axis;

said coupling comprising:

a plurality of segments attached to one another end to end surrounding said first end of said pipe element;

adjustable attachment members positioned at each end of said segments for attaching said segments to one another;

at least one arcuate projection positioned on one side of each of said segments and engaged with said first groove, said at least one arcuate projection comprising a plurality of mating surfaces including:

a first mating surface oriented perpendicular to said longitudinal axis and in facing relation with said first sub-surface;

a second mating surface oriented perpendicular to said longitudinal axis and in facing relation with said second sub-surface;

a third mating surface oriented at an angle with respect to said longitudinal axis and contacting said third sub-surface; and

a fourth mating surface in facing relation with said fourth sub-surface; wherein

said at least one arcuate projection comprises a recess therein forming a gap between said fourth mating surface and said fourth sub-surface.

In accordance with a third aspect of the present disclosure, there is provided, in combination, in combination, a pair of pipe elements and a coupling for joining said pipe elements, said coupling comprising:

a plurality of segments attached to one another end to end surrounding a central space for receiving said pipe elements;

adjustable attachment members positioned at each end of said segments for attaching said segments to one another;

at least a first arcuate projection positioned on a first side of each of said segments, said first arcuate projections comprising a plurality of mating surfaces including:

a first mating surface oriented at an angle with respect to a longitudinal axis extending through said central space coaxially with said segments;

a second mating surface in spaced relation from said first mating surface and oriented at an angle with respect to said longitudinal axis;

a third mating surface contiguous with said first mating surface and oriented at an angle with respect to said longitudinal axis; and

a fourth mating surface between said third and second mating surfaces and oriented at an angle with respect to said longitudinal axis;

each of said pipe elements comprising:

a sidewall surrounding said longitudinal axis and defining a bore, said sidewall having an outer surface;

a first groove positioned in said outer surface, said first groove extending circumferentially around said bore and positioned proximate to said first end, said first groove being defined by a first plurality of sub-surfaces of said outer surface including:

a first sub-surface oriented at an angle with respect to said longitudinal axis and in facing relation with said first mating surface;

a second sub-surface oriented at an angle with respect to said longitudinal axis and in facing relation with said second mating surface;

a third sub-surface oriented at an angle with respect to said longitudinal axis and contacting said third mating surface; and

a fourth sub-surface in facing relation with said fourth mating surface; wherein

said first arcuate projection comprises a recess therein forming a gap between said fourth mating surface and said fourth sub-surface.

In accordance with a fourth aspect of the present disclosure, there is provided, in combination, a coupling and a pipe element having first and second ends oppositely disposed, said coupling comprising:

a plurality of segments attached to one another end to end surrounding said first end of said pipe element;

adjustable attachment members positioned at each end of said segments for attaching said segments to one another;

at least a first arcuate projection positioned on a first side of each of said segments, said first arcuate projections comprising a plurality of mating surfaces including:

a first mating surface oriented at an angle with respect to a longitudinal axis extending through said central space coaxially with said segments;

a second mating surface in spaced relation from said first mating surface and oriented at an angle with respect to said longitudinal axis;

a third mating surface contiguous with said first mating surface and oriented at an angle with respect to said longitudinal axis;

a fourth mating surface between said third and second mating surfaces and oriented at an angle with respect to said longitudinal axis;

said pipe element comprising:

a sidewall surrounding said longitudinal axis and defining a bore, said sidewall having an outer surface;

a first groove positioned in said outer surface, said first groove extending circumferentially around said bore and positioned proximate to said first end, said first groove being defined by a first plurality of sub-surfaces of said outer surface including:

a first sub-surface oriented perpendicular to said longitudinal axis and in facing relation with said first mating surface;

a second sub-surface oriented perpendicular to said longitudinal axis and in facing relation with said second mating surface;

a third sub-surface oriented at an angle with respect to said longitudinal axis and contacting said third mating surface; and

a fourth sub-surface in facing relation with said fourth mating surface; wherein said first arcuate projection comprises a recess therein forming a gap between said fourth mating surface and said fourth sub-surface.

Brief Description of Drawings

Figure 1 is a longitudinal sectional view of a pipe joint according to the prior art;

Figure 2 is an isometric view of an example combination coupling and pipe elements according to the invention;

Figure 3 is a longitudinal sectional view of a portion of an example coupling and pipe elements according to the invention shown initially upon assembly;

Figure 3A is a longitudinal sectional view of a portion of another example coupling and pipe elements according to the invention;

Figure 3B is a longitudinal sectional view of the portion of the example coupling and pipe elements shown in Figure 3 in the fully loaded condition;

Figure 4 is a partial longitudinal sectional view of an example pipe element according to the invention; and

Figure 5 is a partial longitudinal sectional view illustrating a device and a method for forming pipe elements according to the invention.

Detailed Description

What is claimed is:

1. In combination, a pipe element having first and second oppositely disposed ends and a coupling, said pipe element comprising:

a sidewall surrounding a longitudinal axis and defining a bore, said sidewall having an outer surface;

a first groove positioned in said outer surface, said first groove extending circumferentially around said bore and positioned proximate to said first end, said first groove being defined by a first plurality of sub-surfaces of said outer surface including:

a first sub-surface oriented at an angle with respect to said longitudinal axis and facing away from said first end;

a second sub-surface oriented at an angle with respect to said longitudinal axis, said second sub-surface being in spaced relation away from and facing toward said first sub-surface;

a third sub-surface contiguous with said first sub-surface, said third sub-surface oriented at an angle with respect to said longitudinal axis and sloping toward said second sub-surface; and

a fourth sub-surface contiguous with said third and second sub surfaces, said fourth sub-surface being oriented at an angle with respect to said longitudinal axis;

said coupling comprising:

a plurality of segments attached to one another end to end surrounding said first end of said pipe element;

adjustable attachment members positioned at each end of said segments for attaching said segments to one another;

at least one arcuate projection positioned on one side of each of said segments and engaged with said first groove, said at least one arcuate projection comprising a plurality of mating surfaces including:

a first mating surface oriented at an angle with respect to said longitudinal axis and in facing relation with said first sub-surface;

a second mating surface oriented at an angle with respect to said longitudinal axis and in facing relation with said second sub-surface;

a third mating surface oriented at an angle with respect to said longitudinal axis and contacting said third sub-surface; and

a fourth mating surface in facing relation with said fourth sub-surface; wherein

said at least one arcuate projection comprises a recess therein forming a gap between fourth mating surface and said fourth sub-surface.

2. The combination according to claim 1, wherein said coupling comprises no more than two said segments.

3. In combination, a pipe element having first and second oppositely disposed ends and a coupling, said pipe element comprising:

a sidewall surrounding a longitudinal axis and defining a bore, said sidewall having an outer surface;

a first groove positioned in said outer surface, said first groove extending circumferentially around said bore and positioned proximate to said first end, said first groove being defined by a first plurality of sub-surfaces of said outer surface including:

a first sub-surface oriented at an angle with respect to said longitudinal axis and facing away from said first end;

a second sub-surface oriented at an angle with respect to said longitudinal axis, said second sub-surface being in spaced relation away from and facing toward said first sub-surface;

a third sub-surface contiguous with said first sub-surface, said third sub-surface oriented at an angle with respect to said longitudinal axis and sloping toward said second sub-surface; and

a fourth sub-surface contiguous with said third and second sub surfaces, said fourth sub-surface being oriented at an angle with respect to said longitudinal axis;

said coupling comprising:

a plurality of segments attached to one another end to end surrounding said first end of said pipe element;

adjustable attachment members positioned at each end of said segments for attaching said segments to one another;

at least one arcuate projection positioned on one side of each of said segments and engaged with said first groove, said at least one arcuate projection comprising a plurality of mating surfaces including:

a first mating surface oriented perpendicular to said longitudinal axis and in facing relation with said first sub-surface;

a second mating surface oriented perpendicular to said longitudinal axis and in facing relation with said second sub-surface;

a third mating surface oriented at an angle with respect to said longitudinal axis and contacting said third sub-surface; and

a fourth mating surface in facing relation with said fourth sub-surface; wherein

said at least one arcuate projection comprises a recess therein forming a gap between said fourth mating surface and said fourth sub-surface.

4. The combination according to claim 3, wherein said coupling comprises no more than two said segments.

5. In combination, a pair of pipe elements and a coupling for joining said pipe elements, said coupling comprising:

a plurality of segments attached to one another end to end surrounding a central space for receiving said pipe elements;

adjustable attachment members positioned at each end of said segments for attaching said segments to one another;

at least a first arcuate projection positioned on a first side of each of said segments, said first arcuate projections comprising a plurality of mating surfaces including:

a first mating surface oriented at an angle with respect to a longitudinal axis extending through said central space coaxially with said segments;

a second mating surface in spaced relation from said first mating surface and oriented at an angle with respect to said longitudinal axis;

a third mating surface contiguous with said first mating surface and oriented at an angle with respect to said longitudinal axis; and

a fourth mating surface between said third and second mating surfaces and oriented at an angle with respect to said longitudinal axis;

each of said pipe elements comprising:

a sidewall surrounding said longitudinal axis and defining a bore, said sidewall having an outer surface;

a first groove positioned in said outer surface, said first groove extending circumferentially around said bore and positioned proximate to said first end, said

first groove being defined by a first plurality of sub-surfaces of said outer surface including:

a first sub-surface oriented at an angle with respect to said longitudinal axis and in facing relation with said first mating surface;

a second sub-surface oriented at an angle with respect to said longitudinal axis and in facing relation with said second mating surface;

a third sub-surface oriented at an angle with respect to said longitudinal axis and contacting said third mating surface; and

a fourth sub-surface in facing relation with said fourth mating surface; wherein

said first arcuate projection comprises a recess therein forming a gap between said fourth mating surface and said fourth sub-surface.

6. The coupling according to claim 5, said coupling further comprising:

a second arcuate projection positioned on a second side of each of said segments, said second arcuate projections comprising a plurality of mating surfaces including:

a fifth mating surface oriented at an angle with respect to said longitudinal axis;

a sixth mating surface in spaced relation from said fifth mating surface and oriented at an angle with respect to said longitudinal axis;

a seventh mating surface contiguous with said fifth mating surface and oriented at an angle with respect to said longitudinal axis; and

an eighth mating surface between said sixth and seventh mating surfaces and oriented at an angle with respect to said longitudinal axis.

7. The coupling according to claim 6, wherein said first and fifth mating surfaces have an orientation angle from 80° to 90° with respect to said longitudinal axis.

8. The coupling according to claim 6, wherein said first and fifth mating surfaces have an orientation angle of 89° with respect to said longitudinal axis.

9. The coupling according to claim 6, wherein said third and seventh mating surfaces have an orientation angle from 1° to 25° relative to said longitudinal axis.

10. The coupling according to claim 6, wherein said third and seventh mating surfaces have an orientation angle of 10° relative to said longitudinal axis.

11. The coupling according to claim 6, wherein said second and sixth mating surfaces have an orientation angle of 90° with respect to said longitudinal axis.

12. The coupling according to claim 6, wherein said second and sixth mating surfaces have an orientation angle from 40° to 70° relative to said longitudinal axis.

13. The coupling according to claim 6, wherein said second and sixth mating surfaces have an orientation angle of 50° relative to said longitudinal axis.

14. The coupling according to claim 6, wherein said fourth and eighth mating surfaces have an orientation angle from +5° to −5° with respect to said longitudinal axis.

15. The coupling according to claim 6, wherein said coupling comprises no more than two said segments.

16. The coupling according to claim 5, wherein said first mating surface has an orientation angle from 80° to 90° with respect to said longitudinal axis.

17. The coupling according to claim 5, wherein said first mating surface has an orientation angle of 89° with respect to said longitudinal axis.

18. The coupling according to claim 5, wherein said third mating surface has an orientation angle from 1° to 25° relative to said longitudinal axis.

19. The coupling according to claim 5, wherein said third mating surface has an orientation angle of 10° relative to said longitudinal axis.

20. The coupling according to claim 5, wherein said second mating surface has an orientation angle of 90° with respect to said longitudinal axis.

21. The coupling according to claim 5, wherein said second mating surface has an orientation angle from 40° to 70° relative to said longitudinal axis.

22. The coupling according to claim 5, wherein said second mating surface has an orientation angle of 50° relative to said longitudinal axis.

23. The coupling according to claim 5, wherein said fourth mating surface has an orientation angle from +5° to −5° with respect to said longitudinal axis.

24. The coupling according to claim 5, wherein said coupling comprises no more than two said segments.

25. In combination, a coupling and a pipe element having first and second ends oppositely disposed, said coupling comprising:

a plurality of segments attached to one another end to end surrounding said first end of said pipe element;

adjustable attachment members positioned at each end of said segments for attaching said segments to one another;

at least a first arcuate projection positioned on a first side of each of said segments, said first arcuate projections comprising a plurality of mating surfaces including:

a first mating surface oriented at an angle with respect to a longitudinal axis extending through said central space coaxially with said segments;

a second mating surface in spaced relation from said first mating surface and oriented at an angle with respect to said longitudinal axis;

a third mating surface contiguous with said first mating surface and oriented at an angle with respect to said longitudinal axis;

a fourth mating surface between said third and second mating surfaces and oriented at an angle with respect to said longitudinal axis;

said pipe element comprising:

a sidewall surrounding said longitudinal axis and defining a bore, said sidewall having an outer surface;

a first groove positioned in said outer surface, said first groove extending circumferentially around said bore and positioned proximate to said first end, said first groove being defined by a first plurality of sub-surfaces of said outer surface including:

a first sub-surface oriented perpendicular to said longitudinal axis and in facing relation with said first mating surface;

a second sub-surface oriented perpendicular to said longitudinal axis and in facing relation with said second mating surface;

a third sub-surface oriented at an angle with respect to said longitudinal axis and contacting said third mating surface; and

a fourth sub-surface in facing relation with said fourth mating surface; wherein said first arcuate projection comprises a recess therein forming a gap between said fourth mating surface and said fourth sub-surface.