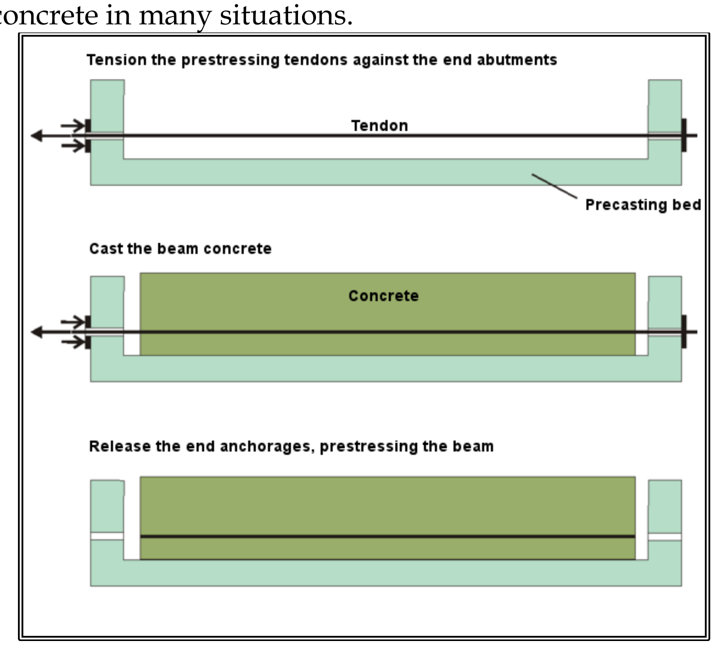
Post Tensioned / Pre-stressed bridges in Ethiopia

1 What is PC bridge?

Pre-stressed concrete is a concrete construction material which is placed under compression prior to it supporting any applied loads (i.e. it is "pre" stressed). A more technical definition is ("*Structural concrete in which internal stresses have been introduced to reduce potential tensile stresses in the concrete resulting from loads*). This compression is produced by the tensioning of high-strength "tendons" located within or adjacent to the concrete volume, and is done to improve the performance of the concrete in service. Tendons may consist of single wires, multi-wire strands or threaded bars, and are most commonly made from high-tensile steels, carbon fibre or aramid fibre. The essence of prestressed concrete is that once the initial compression has been applied, the resulting material has the characteristics of high-strength concrete when subject to any subsequent compression forces, and of ductile high-strength steel when subject to tension forces. This can result in improved structural capacity and/or serviceability compared to conventionally reinforced concrete in many situations.



This term is commonly used in Pre-Stressed concrete and explained in groups as per usage. Regarding steel material that mainly consisting the structure are defined as follow:-

Wire :- A single unit made of steel. Strands Two, three or seven wires are wound to form a pre-stressing strand.

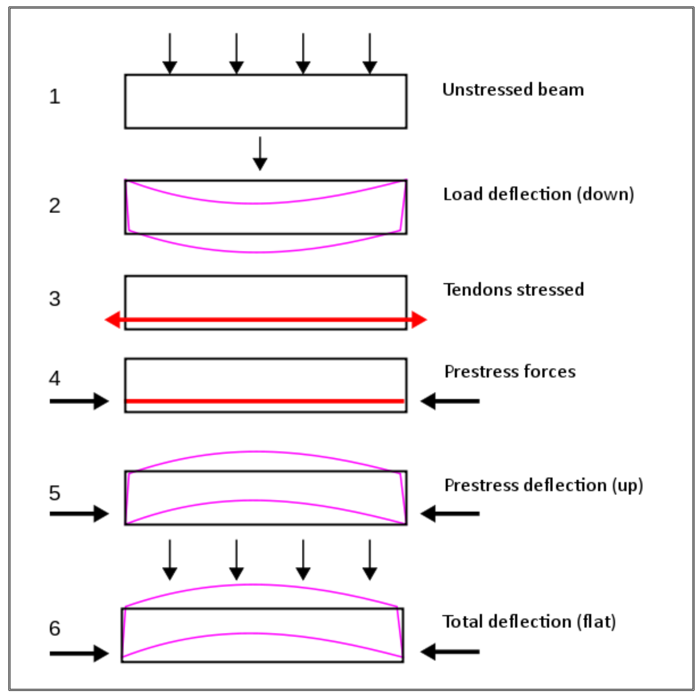
Tendon :-A group of strands or wires are wound to form a pre-stressing tendon.

Cable :- A group of tendons form a pre-stressing cable.

Bars :- A tendon can be made up of a single steel bar. The diameter of a bar is much larger than that of a wire.

The actual pre-stressing of steel process is different. Nature of Concrete-Steel Interface Bonded tendon When there is adequate bond between the pre-stressing tendon and concrete, it is called a bonded tendon.

Pre-tensioned and grouted post-tensioned tendons are bonded tendons.



Unbonded tendon - When there is no bond between the pre-stressing tendon and concrete, it is called unbonded tendon. When grout is not applied after post-tensioning, the tendon is an unbonded tendon.

There are different stages of Loading. The analysis of pre-stressed members can be different for the different stages of loading.

The stages of loading are as follows.

1) Initial : It can be subdivided into two stages.

a) During tensioning of steel

b) At transfer of pre-stress to concrete.

2) Intermediate : This includes the loads during transportation of the pre-stressed members.

3) Final : It can be subdivided into two stages.

a) At service, during operation.
b) At ultimate, during extreme events.

2 Advantages of PC bridges from other type

Many bridge designers are surprised to learn that precast, pre-stressed concrete bridges are usually lower in first cost than all other types of bridges. Coupled with savings in maintenance, precast bridges offer maximum economy.

The pre-stressing of concrete has several advantages as compared to traditional reinforced concrete (RC) without pre-stressing. A fully pre-stressed concrete member is usually subjected to compression during service life. This rectifies several deficiencies of concrete.

The precast pre-stressed bridge system offered two principal advantages:

it was *economical* and it provided *minimum downtime* for construction.

The fast construction of precast concrete integral deck bridges is a key advantage. Precast concrete bridges can be installed during all seasons and opened to traffic more rapidly than any other permanent type of bridge, because of the availability of plant-produced sections and the speed of erecting and finishing construction.

To accurately compare costs, consider a bridge's life-cycle: The initial cost of the structure must be added to the total operating cost.

For stationary bridges, the operating cost is the maintenance cost.

Life Cycle Cost = Initial Structure + Total Operating Costs (Maintenance)

The following advantages can be listed for detail purpose:-

1) Section remains uncracked under service loads
- Reduction of steel corrosion
- Increase in durability.
- Full section is utilized
- Higher moment of inertia (higher stiffness)
- Less deformations (improved serviceability)
- Increase in shear capacity.
- Suitable for use in pressure vessels, liquid retaining structures.
- Improved performance (resilience) under dynamic and fatigue loading.

2) High span-to-depth ratios

Larger spans possible with pre-stressing (bridges, buildings with large column-free spaces)
Typical values of span-to-depth ratios in slabs are given below.

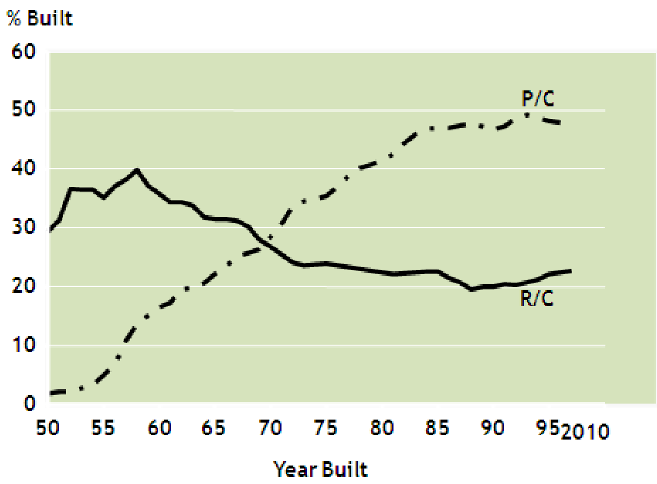
Non-pre-stressed slab 28:1
Pre-stressed slab 45:1

For the same span, less depth compared to RC member.
- Reduction in self-weight
- More aesthetic appeal due to slender sections
- More economical sections.

3) Suitable for precast construction

- Rapid construction
- Better quality control
- Reduced maintenance
- Suitable for repetitive construction
- Multiple use of formwork and reduction of formwork
- Availability of standard shapes.

The following graph shows how the Pre-stressed type bridge became popular and favorite in the world since 1950, its start time comparing to the ordinary type RC bridges.

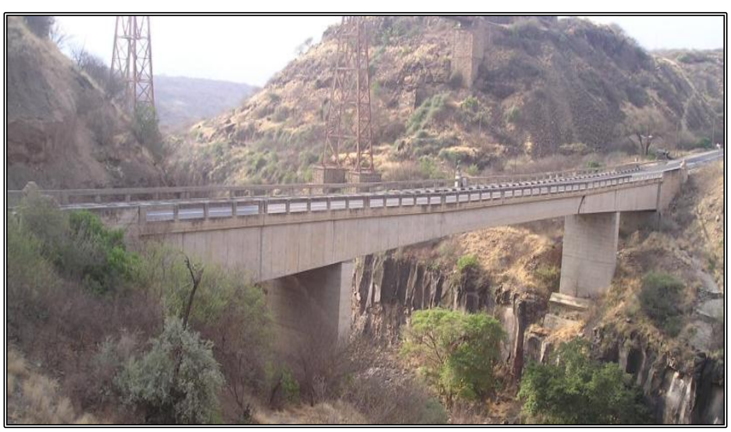


Source: National Bridge Inventory Data

3 Ethiopian Post Tension Bridges

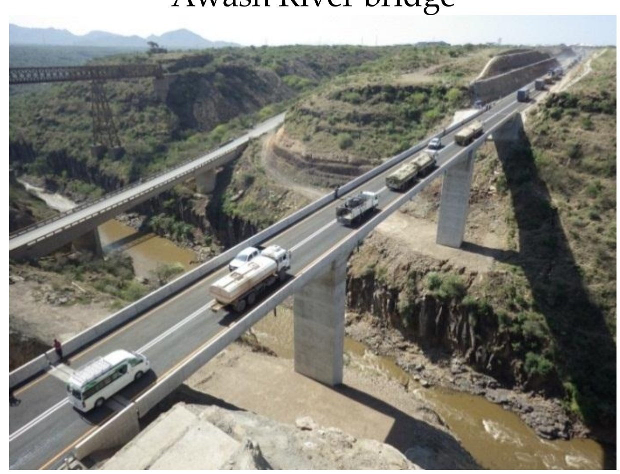
There are very few PC bridges in Ethiopia. Brief profile of well-known PC bridges is shown in the under table.

As we can see almost all these bridges are designed and constructed by foreign bridge experts. Many Ethiopian Engineers have keen interest to design and construct such bridges by themselves. But, there are many shortages like design experience and availability of tools and equipment necessary to apply the whole pre stressing process. The question is how many such bridges really do we need to construct in Ethiopia that deserve high investment to transfer knowledge and avail equipment?

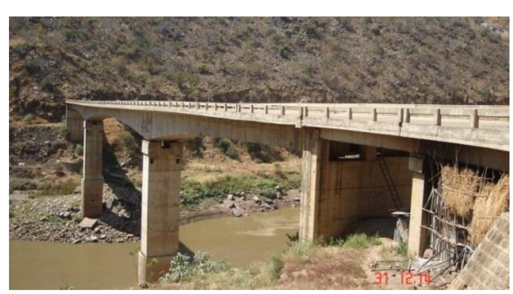


It. No.	Bridge Name	Location, District, Km from AA	Bridge Length, Mt	Construction Year	Designer / Contractor
1	Awash	DireDawa, 227	109	1971	Dr Ing. Trapp & Co. / GMBH, wesel, Germany
2	Abay No. 5	Debre Marcos, 465	265	1989	Sir. Wiliam Halcow & Partn / Blue Nile Construction
3	Awash	DireDawa, 227	145	2015	Central Consultant Inc / Sato Kogyo Co. Ltd.(SKC) Japan
4	Abay N0.6	Debre Marcos, 209	303	2008	
5	Abay N0.8	Combolcha, 620.4	285	2015	Lee in JV with Scot Willson / CGCOC
6	Wekela	Combolcha, 623	140	2015	
7	Gibe	Jimma, 180	118	2003	INTEGRA / Salini

Awash River bridge



New Awash bridge



Abay No 5 Bridge

Abay No. 6 Bridge

Abay No.8 Bridge

Wakela River Bridge

The following pictures demonstrate how the existing old Gibe bridge was externally pre-stressed and strengthened in 2003 to carry about 150 ton.

Source

- *Wikipedia*
- *ERA Bridge Management System*

Anchor blocks reinforcement grouting

cable tensioning

Cable tensioning

Externally tensioning cables

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