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Future of High Speed Trains in India and Its Comparative Study with Japan, France, Germany and South Korea.

Shubham Sharma[1], Annu[2]
[1]*Student , Department of Civil Engineering, Maharishi Markandeshwar University,Ambala, Haryana, India..*
[2]*Asisstant Professor, Department of Civil Engineering, Maharishi Markandeshwar University,Ambala, Haryana, India..*

Abstract: *India's population has skyrocketed to about 122 crores .In such a scenario a high speed train technology for a swift transportation of the ever-increasing population is required .Not only speed is the sole aim but passenger safety, comfort and punctuality in railways is the need of the hour. Indian railways are subjected to regular delays in their railway setup. This comparative study focuses on various already existing high speed train technologies across four major countries of Japan, France , Germany and South Korea. The break-through was made by Japan by introducing Shinkansen (Bullet Trains) followed by the French Train Grande Vitesse. Germany and South Korea too followed the French by introducing Inter City Express and Korea Train Express respectively. Since the development of high-speed train technology in India is still in the beginning phase, the study also analyses its future in India. The study is also based on the existing setup and technology of Indian railways and gives some recommendations.*

Key Words: *High Speed Train, Inter City Express, Korea Train Express, Shinkansen , Train Grande Vitesse*

I. Introduction

High speed rail transport is a type of rail transport that runs faster than the conventional railway systems in a country. The European Union system has mentioned a minimum speed of 250 Km/h for high-speed dedicated tracks and 200 km/h for existing tracks [1]. At present Indian railways is aiming to provide a speed of 250 km/h for its proposed high speed trains. Different countries have developed different types of technologies for their high speed railways. However this study is confined to the comparison of such technology of 4 countries viz-Japan, France, Germany and S.Korea . Japanese were the first to introduce High speed train network in their country called as "Shinkansen". The French developed their high speed train system named TGV ie-"Train Grande Vitesse" in the 1970s. German system is called the ICE (Intercity Express) and the S.Korean one is the KTX(Korea Train Express).

II. Basic Technological Differences

2.1 Line

It is a general practice for high speed train systems to develop a dedicated separate rail network separated from the existing one to avoid any crossings, sharp curves and any trespassing that may result into fatal accidents. Shinkansen routes are completely separate from conventional rail lines .Consequently Shinkansen is not affected by slower local or freight trains and has the capacity to operate many high-speed trains punctually. The lines have been built without road crossings at a grade. Tracks are strictly off-limits with penalties against trespassing strictly regulated by law. It uses tunnels to go through and over obstacles rather than around them, with a minimum curve radius of 4,000 meters. The ICE however differs from TGV and Shinkansen in track routing. Unlike the French TGV or the Japanese Shinkansen systems, the vehicles, tracks and operations were not designed as an integrated whole; rather, the ICE system has been integrated into Germany's pre-existing system of railway lines instead. One of the effects of this is that the ICE 3 trains can reach a speed of 300 km/h (186 mph) only on some stretches of line and cannot currently reach their maximum allowed speed of 330 km/h on German railway lines (though a speed of 320 km/h is reached by ICE 3 in France).The KTX system has also integrated such systems with its existing system, However such integration is not possible in India because Indian railway grid is already too weak at many critical sections to bear any further wear and tear of such high speeds. Sharing a line between fast and slow traffic reduces its maximum carrying capacity by a very large factor, by forcing much longer intervals between trains at the two different speeds.

2.2 Tracks

Continuous welded rail is generally used to reduce track vibrations and misalignment. Constrictions, such as at-grade crossings, where lines intersect other lines and/or roadways are eliminated. However high speed trains use a standard track gauge. Table 1 shows various track gauges for these trains.

Table-1:- Track Gauges for high speed railways across the world.[2]

Country	System	Gauge
Japan	Shinkansen	Standard(1435 mm)
France	TGV	Standard(1435 mm)
Germany	ICE	Standard(1435 mm)
South Korea	KTX	Standard(1435 mm)
India	Indian Railways	Broad(1676 mm)

Since Indian track gauge is broader than these nations India has to develop its high speed railway for broader one to keep provisions for future integration and high passenger capacity.

2.2.1 Jointing and Crossings

Most modern railways use continuous welded rail (CWR), sometimes referred to as ribbon rails [3]. In this form of track, the rails are welded together by utilising flash butt welding to form one continuous rail that may be several kilometres long. Because there are few joints, this form of track is very strong, gives a smooth ride, and needs less maintenance; trains can travel on it at higher speeds and with less friction. Welded rails are more expensive to lay than jointed tracks, but have much lower maintenance costs. If not restrained, rails would lengthen in hot weather and shrink in cold weather. To provide this restraint, the rail is prevented from moving in relation to the sleeper by use of clips or anchors. Joints are used in continuous welded rail when necessary, usually for signal circuit gaps. Instead of a joint that passes straight across the rail, the two rail ends are sometimes cut at an angle to give a smoother transition. In extreme cases, such as at the end of long bridges, a breather switch (referred to in North America and Britain as an expansion joint) gives a smooth path for the wheels while allowing the end of one rail to expand relative to the next rail. However the Conventional Indian system is still using “fish plates’ that may prove very weak for such high speed. They also make ‘clip-clap’ sounds when the wheel rim passes over them. All the four countries Japan, France ,Germany and S.Korea use continuously welded rail tracks with expansion joints.

Fig 1:- A typical tapered expansion joint used in the French TGV.

As far as the station inter-track crossings are concerned the Shinkansen, TGV and the KTX use Swingnose crossings while the ICE is still using V-crossings as that of India. This reduces the train speed especially at junctions. A Swingnose crossing is used at a railway turnout to eliminate the gap at the common crossing which can cause damage and noise .On the other hand on a fixed railway crossing, the wheels need only drift by a small angle, say 1 in 20, before the vehicle may start to go in the wrong direction at the V of a V-crossing. This problem can limit the maximum speed of vehicles using the crossing. In addition, the open gap at a fixed V-crossing forms a weak point on the railway line where the heavily loaded wheel must bump across the resulting gap of about 10 cm, supported only by the portion of the wheel tread which is on the wing rail. This pounds the rail so much that the steel can deform and wear away. This damage may easily spread to other components including the wheels that may prove to be disastrous.

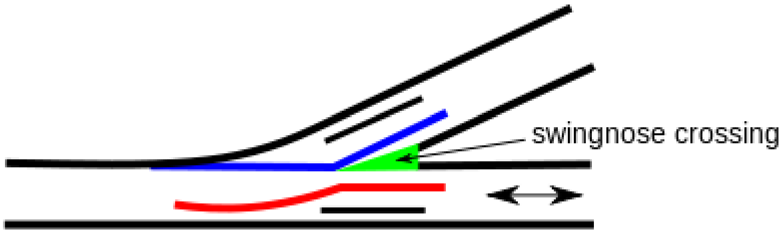

Fig 2:- A swingnose crossing junction

2.2.2 Ballast and sleeper arrangement

The Shinkansen uses ballastless tracks and concrete sleepers to bear the enormous load of the train. The TGV , ICE and the KTX use a combination of both. A combination of ballasted and slab track are used, with slab track exclusively employed on concrete bed sections such as viaducts and tunnels. Slab track is significantly more cost-effective in tunnel sections, since the lower track height reduces the cross-sectional area of the tunnel, thereby reducing construction costs by up to 30%. All of these use ladder system of sleepers. Ladder track utilizes sleepers aligned along the same direction . The Indian system is exclusively ballasted one using crushed stones frequently demanding its maintenance.

2.3 Signalling

All the four countries use In-Cab signaling however the method transmission of data is different [4]. It communicates track status information to the cab, crew compartment or driver's compartment of a train where the train driver can see the information continuously.The simplest systems display the trackside signal or a simplified set thereof, while more sophisticated systems also display allowable speed, location of nearby trains, and dynamic information about the track ahead. Cab signals can also be part of a more comprehensive train protection system that can automatically apply the brakes and bring the train to a stop if the operator does not respond appropriately to a dangerous condition. Modern High-speed rail systems such as those in Japan, France, and Germany were all designed from the start to use in cab signalling due to the impracticality of sighting wayside signals at the new higher train speeds. The Shinkansen uses a combination of magnetic, wireless and track circuit systems while the TGV, KTX and ICE use track circuit systems for cab signaling. Indian system is still based on sighting the wayside track signals. Thus passenger safety would necessitate India to have rolling stock with in cab signaling.

2.4 Braking

The Indian system uses continuous vacuum brakes having air reservoir in each bogie along with dynamic brakes which are electrically driven . They use the air or vacuum pressure to hold the brakes off against a reservoir carried on each vehicle, which applies the brakes if pressure/vacuum is lost in the train pipe.

Automatic brakes are thus largely "fail safe", though faulty closure of hose taps can lead to accidents [5]. On the other hand Shinkansen uses 'Dynamic Brakes" using eddy currents for safe stoppage of trains. KTX and the ICE too use dynamic disk braking system. The TGV uses a combination of both disk brakes and magnetic levitised system. These brakes are much more efficient , take less time in stopping of train and offer greater control on speed as compared to vacuum brakes.

2.5 Rolling Stock

All the four technologies use standard "Jacobian type articulated vehicles". It is a vehicle which has a permanent or semi-permanent pivoting joint in its construction, allowing the vehicle to turn more sharply. Instead of being underneath a piece of rolling stock, Jacobs bogies are placed between two car body sections.

The weight of each car is spread on one half of the Jacobs bogie. Such trains are less prone to collapse during derailing because of high stiffness provided by them [6]. This high stiffness also reduces weight that causes the train to negotiate sharp curves very easily. The only disadvantage is that the vehicles are semi-permanently coupled and can only be separated in the workshop thus new bogies can not be added whenever required. Generally for passenger traffic two TGVs or Shinkansens are coupled together.KTX generally comes with 18-21 bogies.

Fig 3:- An articulated bogie of a German ICE

Fig 4:- Schematic diagram showing an articulated Jacobian train.

The cars of these trains are also pressurized to prevent high noise and tunnel booms.[7]

III. Station Design

The TGVs owing to its high cost integrates its high speed dedicated lines with existing stations by slight modifications. Same method has been used as in case of the ICE and KTX. However the Shinkansen developed exclusively new stations for its high speed railways[8]. As far as India is concerned very few Indian Stations can be compatible with the new technology. Most of the stations in Indian cities are generally at the city centres that would necessitate regular bridges, tunnels and crossings. Also lack of space would pose serious problems and raise construction cost. Thus Indian railways will have to develop separate portals for such cities where there is no space left.

Modern station would need to integrate more passenger capacity, efficient track change system, efficient platform management, more booting space, regular track and platform maintenance and also measures for passenger safety at platforms owing to abrupt braking and high speeds of such trains.

IV. Construction Cost

Japanese systems are often more expensive than their counterparts, because they run on dedicated elevated guideways, avoid traffic crossings and incorporate disaster monitoring systems. The largest part of Japan's cost is for boring tunnels through mountains, as was also true in Taiwan.

In France, the cost of construction (which was €10 million/km (US$15.1 million/km) for LGV) is minimized by adopting steeper grades rather than building tunnels and viaducts. However, in mountainous Switzerland, tunnels are inevitable. Because the lines are dedicated to passengers, gradients of 3.5%, rather than the previous maximum of 1–1.5% for mixed traffic, are used. More expensive land may be required in order to minimize curves. This increases speed, reduces construction costs and lowers operating and maintenance costs. In other countries high-speed rail was built without those economies so that the railway can also support other traffic, such as freight. Experience has shown however, that running trains of significantly different speeds on one line substantially decreases capacity. As a result, mixed-traffic lines usually reserve daytime for high-speed trains and run freight at night.

RITES is currently performing a feasibility study [9].According to news media, the costs for constructing such rail lines in India are estimated to be Rs 700-1000 million per km (US$15–22 million/km). Therefore, the Mumbai-Ahmedabad route of 500 km, will cost Rs 370 billion (US$8.04 billion) to build and to make a profit, passengers will have to be charged Rs 5 per km (US$0.11/km). Delhi to Amritsar one-way, a distance of 450 km, will cost about Rs 2000 (US$43.48)[10] . At US$15–22 million per km, cost estimates are in line with US$18 million per km of the recently completed Wuhan-Guangzhou HSR line in China. The Mumbai - Ahmedabad line is expected to cost Rs 650 billion [10].

V. Conclusion

From the above studies it is clear that India needs to reanalyze its entire railway system before commencing the construction for high speed rail network. Existing system is still using many technologies that are obsolete in these four countries. A comprehensive plan for the upgradation of existing system is the need of hour. These may include upgradation of tracks, traction and power systems, rolling stock, signaling and braking systems, passenger safety, passenger information system, cleanliness and maintenance, disaster management and above all time management. From cost consideration huge sums of investment, technical know-how and regular funding is required especially in a country where such a huge upgradation is required. A dedicated track (better if broad) segregated from existing congested grid with all the new advancements would be the only solace to the sleeping economy of India that has one of its edifice on railways.

References

[1] European Union Directive 96/48/EC, Annex 1
[2] http://cs.trains.com/trn/f/111/t/136688.aspx
[3] Grandad Sez ,Continuous Welded Rail, Grandad's Railway Engineering Section.
[4] General Railway Signal (June 1979), Elements of Railway Signaling General Railway Signal.
[5] Marsh, G.H. and Sharpe, A.C, The development of railway brakes. Part 1 1730-1880
[6] Eurostar train derails in France, BBC News. 2000-06-05.
[7] Alstom Citadis, Siemens S,Articulated Passenger Trains, including: Eurostar, Thalys, Advanced Passenger Train, Talgo, Korea Train Express.
[8] Smith, Roderick A. (2003), "The Japanese Shinkansen", The Journal of Transport History (Imperial College, London) **24/2**: 222–236.
[9] Bullet train, Rlys studying feasibility report - Feb 22, 2010, THE TIMES OF INDIA.
[10] Runaway Train, High-speed trains could be the Indian Railways' answer to low-cost airlines - Nov 5, 2009, Forbes India.