Study on the Urban Integration of Shanghai’s Maglev Technology

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Abstract

As the first commercially operated train to incorporate electromagnetic suspension, it is essential to analyze how the Shanghai maglev train has implemented itself into the city of Shanghai. This research analyzes the efficiency of maglev technology and its consistency in successfully operating at a commercial level. It analyzes the urban setting of Shanghai, and the impact electromagnets have had on the landscape. Deformation and environmental vibration are linked to maglev technology and its severity is analyzed. The reversibility of these adverse effects is studied, and methods of monitoring are proposed. This study aims to identify the replicability of maglev technology in other urban cities across the world.

Index Terms: Intercity and urban application; Ground subsidence; Shanghai maglev; Environmental vibration; Maintenance protocols; Electromagnetic suspension.

I Introduction

The Shanghai Maglev Train, otherwise known as the Shanghai Transrapid, is the first, the fastest, and the only operational Maglev train of its kind in the world. Inaugurated in December 31, 2002, the Shanghai Maglev Train resides in the centermost city of Shanghai, China. It connects two highly transported destinations, the Longyang Road Station and the Pudong International Airport Station for a continued operation of 15 hours/day, 7 days/week. The Shanghai Maglev currently connects thirty kilometers, a distance traveled in just under eight minutes. These short times combined with an exceptional top operational velocity of 430km/h place the Shanghai transrapid in a league of its own. The unique incorporation of magnetic levitation sets it apart from its competitors and gives it drastic advantages in comparison to other conventional trains. Magnetic levitation, as the name suggests, operates through magnetic attraction and propulsion forces. The laws of physics illustrate this as: like forces pull to each other and opposite forces push away from each other. The combination and configuration of these behaviors are shifted electronically to maintain the Shanghai Maglev always levitating over its tracks. As maglev technology becomes widely recognized and innovators push towards recreating these train systems internationally, it is essential to analyze the successful integration of the Shanghai Maglev Train in the urban city of Shanghai. This study will analyze the electromagnetic suspension which categorizes the Shanghai Maglev to determine the adverse effects magnetic fields, and their nature to vibrate have on civilians nearby. The infrastructure that operates this technology will also be analyzed to determine the geological effect such heavy technology can have on an urban terrain and how this directly impacts the longevity of maglev trains. It is essential to recognize these concerns to implement a method of maintenance that can be universally applied and translated to similar technologies globally.

II. Urban Integration

The 2002 implementation of the Shanghai Maglev Train line illustrates revolutionary advancements in the way people connect and travel. [3] Research on Environmental Vibration Induced by High-Speed Maglev Transportation identifies the urgency of this transportation worldwide by stating, "With the increasing pressure of traffic congestion and environmental conservation, it has become necessary to encourage the development of…maglev transportation [which] offers a new form of convenient high-speed urban railway transit." The Shanghai Transrapid, designed with a TR-08 train carrier that is divided into five sections, has a cumulative carrying capacity of roughly five-hundred passengers. [4] To quantify the operational efficiency of the Shanghai maglev a research analysis finds that, "Till the end of May 2005, [Shanghai Maglev] operated safely and reliably for 883 days, [traveling a cumulative distance of] 1.56 Mkm and carried 3.51 M passengers." The operational success of the Shanghai Maglev is a direct response to researchers attempting to identify safer and faster methods of transportation. [2] To defend his claim that the Maglev train would be better developed in China, research concludes, "Maglev train offers numerous advantages, such as the elimination of much noise and vibration, the reduction in maintenance costs and so on (Lee et al. 2006; Yan 2008)." In an analysis of operational velocity in dependence on acceleration researchers discovered that [4] "The small bending radius (50–70 m) and high climbing capability (7–10%) make the maglev especially suitable for areas with small space and high roughness". At a glance, the success of the Shanghai Maglev appears exceptionally perfect.

III. EMS Vibrations

Electromagnetic suspension operates by manipulating the attractive force between iron-core electromagnets and ferromagnetic rails. The nature of this technology relies on the continuously active suspension force adjustment, a shifting movement which creates vibrations. These vibrations occur consistently to properly operate and suspend the train above its tracks. To operate and maintain steadiness, magnetic levitation suspension (EMS) relies on controlled adjustment of magnetic forces. [3] To analyze the environmental impact of this shift in magnetic forces, research identifies "During the running of a maglev train, the vehicle and railway track constantly vibrate and propagate the vibration to the surrounding environment, which affects the surrounding environment and may cause serviceability problems or even vibration pollution." [2]In a study analyzing ground deformation near the Maglev train line, researchers identified "the deformation of the soil layer above the bearing stratum was mainly induced by vibration load caused by the operation of Maglev train, which induced the dissipation of excess pore water pressure and contributed to the consolidation of surrounding soil." The intricate design of the maglev train, being both fast and short in distance, pave the way for complex ground vibrations that interfere with each other. Many components influence the severity of these vibrations, including the beams that suspend the tracks. The research [3] discovers the vibrations have significant effects on the infrastructure of the maglev track itself, finding that the impact as the train passes from girder to girder can be up to 20 m/s^2. In conjunction to this, the findings also discover that the vibrations have no negative effects to humans. It estimates a ground vibration lower than the human perception threshold, making it an extremely suitable method of transportation for urban settings.

IV. Geological Settlement

China's wide territory, large population, and rapidly developing economy made it a perfect host for the Maglev train. It offered the Chinese population a revolutionary method of transportation that was faster, more efficient, quieter, and reduced maintenance costs. Settlements negatively impact the structure of these intricate projects by increasing their internal stress, possibly hindering performance and reducing service life. Maglev operates through repulsion and attraction, pushing the train forward with no physical contact to the floor. Research finds that Shanghai, being located at the fore of the Yangtze River Delta, has soil that is thick and behaves poorly. The effect of the Maglev train on the stability of soil layers can be understood as the settlement grows larger along the magnetic suspension line. To illustrate the geological complications, researchers determined, [2]"The operation of Maglev train can affect the stability of soil layers and increase land subsidence, attention should be paid to it. To avoid the occurrence of differential settlement and ensure the regular service of Maglev train, some special measures must be made." In 44 years between 1921 and 1965, Shanghai's settlement came to 1.6m due to the over extracting groundwater. This natural occurrence carried adverse effects which hindered Shanghai's construction of subways and large buildings.

V. Regulations and Maintenance

The 3 lines of the Shanghai Metro Line 13 was constructed directly beneath the Shanghai transrapid. This construction required critical supervision and monitoring to preserve the integrity of the transrapid and its Maglev protected area. Concerns were raised about the impact such construction may have in weakening the foundation of the transrapid and how it may affect performance. Research suggests the concept of comprehensive technical monitoring, monitoring the Maglev operation line before, during, and after construction. Automatic Monitoring System automizes the monitoring of settlement and inclination of the piers. In doing so, the system can notify changes and send emergency alerts to halt transportation for safety of the transrapid and any individuals within. The high-speed nature and intricate technologies that power the Shanghai maglev care to ensure damages do not occur that can possibly derail or malfunction the train.

Maintenance Management Core System (MMCS) ensures the safety, reliability, and the economic operation of Shanghai Maglev. It keeps record of all kinds of maintenances operated on the demonstration line to ensure scheduled maintenance is done on time and preventative measures can be taken. Determines that the core systems needed to be supervised are the vehicle subsystem, guideway subsystem, switch subsystem, operational control subsystem, and power supply subsystem.

VI. Conclusion

Maglev technology illustrates breakthrough advancements in modern transportation technologies. It paves the way for new opportunities and inspires neighboring countries to pursue similar infrastructures. This analysis of the different components that are directly impacted by the implementation of the Shanghai Transrapid in the urban setting of Shanghai display the intricate measures necessary that allow for a consistent and successful operation.

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