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ИНЖЕНЕРНЫЕ КОНЦЕПЦИИ ДЛЯ СТРОИТЕЛЬСТВА ЖЕЛЕЗНОДОРОЖНОГО ТЕРМИНАЛА В ГАНЕ

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Растущий спрос на железнодорожный транспорт во всем мире побуждает к дальнейшему развитию инфраструктуры в городских, пригородных и железнодорожных системах Ганы. Создание новых станций и обновление старых являются неотъемлемой частью этого многогранного глобального предприятия. В качестве пунктов прибытия и отправления и узлов интермодальных пассажирских перевозок, терминалы и станции обеспечивают возможность соединения и, следовательно, мобильность в городах, регионах и странах. Чтобы существующие и новые терминалы и станции были готовы к будущему, они должны включать в себя функции и эксплуатационные возможности, которые оправдывают ожидания пассажиров в отношении эффективного и приятного путешествия на поезде. Многие станции уже способствуют социальной и коммерческой деятельности, предоставляя места, где люди могут встретиться, поесть и сделать покупки. Поскольку города изо всех сил пытаются приспособиться к растущему населению, в планах городского развития, ориентированного на транзит (TOD), станции будут использоваться как центральные элементы и магниты для жилого и коммерческого строительства в 21 веке.

Принимая на себя эти роли, терминалы могут продвигать свое собственное развитие и способствовать общей жизнеспособности городов.
Ключевые слова: *железнодорожный вокзал, здание вокзала, архитектурное проектирование, концепции, строительство, сооружения.*

ENGINEERING CONCEPTS FOR THE CONSTRUCTION OF A RAILWAY TERMINAL IN GHANA

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Increasing rail transport demand around the world is prompting more infrastructure development in urban, commuter and rail systems In Ghana. The creation of new stations and the renewal of older ones are integral to this multifaceted global undertaking. As arrival-departure points and intermodal passenger transport hubs, Terminals and stations enable connectivity and thus mobility throughout towns, cities, regions and countries. For existing and emerging Terminals and stations to be future ready, they must incorporate the features and operational capabilities that fulfill passenger expectations for efficient and enjoyable train travel. Many stations already facilitate social and commercial activities by providing places where people can meet, eat and shop. As cities struggle to accommodate growing populations, urban Transit-Oriented Development (TOD) plans will utilize stations as centrepieces and magnets for 21st-century residential and commercial development. By assuming these roles, terminals can advance their own evolvement and contribute to the overall liveability of cities.
Key words: *Railway Terminal; station building; architectural engineering; Concepts; construction, structures.*

1. Introduction

All over the world, railway transportation has remained an important segment in overall logistics business. This is so because railway transport has obvious advantage over other means of transportation in the movement of goods and passengers' overland. In many of these countries, rail transport has retained its pride of place as a veritable source of economic development. But the story is different in Ghana. Rail transport in Ghana has suffered greatly in terms of investment in the sector, growth and contribution to the national economy. Despite a history of almost 122 years, government support has never been adequate and this has led directly to high levels of worn-out railway infrastructure and poor services.

In 21st century the intermodal concept defines the transportation facilities as described in several ways. It could refer to the interaction between people, services, and different modes of transportation. It is also clearly described by Muller (1999) as "the concept of transporting passengers and freight on two or more different modes in such a way that all parts of transportation process, including the exchange of information, are efficiently connected and coordinated" [1]. The need for intermodal transportation centres has grown over the years, and the concept is now considered essential to providing convenience for passengers. Hopkinson and Parkinson (1995) defined the intermodal transportation center as a structure combining various technologies of transportation such as regional trains, light rails, bus lines with centres accessible to airports. Planners include well-designed buildings providing various kinds of integrated services, such as restaurants, newsstands, small shops, and travel information systems [2]. In parallel, the development of the intermodal concept typically pays much attention to utilizing existing infrastructures, for instance, old railway stations or bus terminals which are normally located in central cities. Thus, the use of a centrally located station or terminal supports the view that an intermodal transportation center not only forms an integral part of the urban scene, but has the potential for also becoming a tourist center. This trend has already begun in several cities in both Europe and North America where existing railway stations have been converted to intermodal transportation centres.

In Asian Countries, like Thailand, this concept has also been applied to the old railway structure and the new underground system. As pointed out by Floyd (1993) and Tolliverb (1995), an intermodal transportation center can be a new form of structure, a distinctive building, or a group of buildings at a single location which are intended to introduce new methods and patterns in handling a large number of people. Efficiency requires that the center is designed and constructed to incorporate the latest technologies and innovations. [3]

2. Background of Ghana Railway

For historical reasons, the current rail network only serves the main traffic corridors in then seaboard third of the country, although this is the main area of economic activity. The first lines were built to support and develop mining interests following the discovery of gold-bearing rocks in the Ashanti region, 200 km inland from the coast. The need to move construction equipment inwards and minerals out led to the construction of an initial 66 km route from Sekondi to Tarkwa in 1898 to 1901. Construction north of Tarkwa proved easier and the following 200 km to the country's second city of Kumasi was completed by 1903. After gold was discovered at Prestea, a 29 km branch from Tarkwa was opened in 1908. [4] (source: Railway Gazette International- David Brice, June 2008).

Work began in 1909 on a 304 km line to link the capital Accra with Kumasi, but this was not completed until 1923. Rather than minerals, this line was predicated on the development of cocoa, rubber and timber traffic. Its opening also completed a very circuitous through route between Accra and Sekondi. With the very basic port facilities at Sekondi proving inadequate to handle growing mineral exports, a new deep-water port was opened in 1928 at Takoradi, 6·5 km to the southwest. All railway operations were transferred to the new terminus apart from the extensive workshops which remain near Sekondi. [4] (source: Railway Gazette International-David Brice, June 2008).

Subsequent additions included the 157 km Central Provinces line opened in 1923 from Huni Valley to serve further mineral deposits at Kade, and the important *73* km branch from Dunkwa to serve bauxite mines at Awaso, prompted by heavy demand for aluminium to build aircraft during World War II. In 1953, 82 km link was opened between the Kade branch and the Accra- Kumasi line at Kotoku, shortening the Accra-Takoradi journey by 268 km. The following year saw the completion of a 23 km branch from Achimota Junction, north of Accra, to the port at Tema, which is now becoming increasingly important. [4] (source: Railway Gazette International-David Brice, June 2008).

For administrative purposes the railway is divided into three sectors:

- **Western Line**: Takoradi – Kumasi and branches to Awaso and Prestea;
- **Central Line**: Huni Valley – Kotoku and the Kade branch;
- **Eastern Line**: Accra – Kumasi and the branch to Tema.

The railway is built to 1067 mm gauge, with a maximum axle load of 16 tones. The first line between Takoradi and Dunkwa was built very cheaply and is plagued by severe curvature north of Tarkwa, although some consideration has been given to realignment to ease operations. All lines are single-track except for a 30 km double-track section between Takoradi and Manso. Semaphore signaling was originally installed, but is now only operational on the double-track section. Solar-powered colour-light signaling, funded *by* the World Bank, replaced the mechanical equipment on the Western Line, but the cost of spares soon became prohibitive and the system has now been abandoned. Likewise, the single line token apparatus has fallen into disuse, and train operation and crossing arrangements on the rest of the network are controlled using paper **tickets.** [4] (source: Railway Gazette International- David Brice, June 2008).

The safety of train operations is a major concern for *GRCL,* because of the lack of secure signaling, but also the *very* poor condition of the track and the mineral wagons which convey the bulk of present freight traffic. These vehicles are in continual service, and require a much higher standard of maintenance than they currently receive. Derailments are frequent, caused by bad track or poorly-maintained vacuum brakes and running gear.

Fig. 1. Schematic map of old Rail Network in Ghana

3. STATION DESIGN: A Spatial Analysis

There are fundamental principles of successful railway stations. These defined and shaped the station as a unique typology while ensuring that it offered the patrons of the rail service, comfort and convenience in an environment of a fast-paced movement of the commuters.

The ideas have been discussed and arranged under the following sub-topics:

- Spaces and Activities at a Railway Station;
- Railway Stations as Transportation Nodes;
- Design Approach;
- Qualitative issues of design.

Fig. 2. Schematic map of proposed New Rail Network in Ghana

3.1. Spaces and activities at a railway station

The spatial layout of activities at the stations have now gone beyond the technically required main functions incorporating just the movement of trains and the commuters Many new activities have added to the station premise which can further be segregated as core, transit, peripheral, and administrative areas.

Core areas focus on passenger movement. Conceptually, they can be considered as a circle surrounded by closely related activities and areas that include ticketing, information, baggage handling, reclaiming, and waiting.

Transit areas connect transit facilities to the core areas. They include secondary, but often-essential facilities such as, restrooms, telephones, and commercial spaces.

Peripheral areas support circulation outside the main buildings including platforms, tracks, service areas and parking spaces.

Administrative areas control both traffic and station management. Found only in some station types that provide complex arrangements for handling a large number of passengers. These areas can be isolated from other facilities or inserted among them.

The four areas described above represent the major physical and functional elements considered necessary in understanding a railway station and, consequently, must be included in its design. The interrelationships between the four functional areas collectively make an intermodal station.

To achieve good functional flow among the four areas, and smooth connections in and out of the stations, their physical relationship needs to be linked together.

(I) Additionally, the space capacity must efficiently handle the increasing number of passengers.

(II) Clear routes to other transport modes and to pedestrian ways should be well designed and safe to use. The width of routes should reflect the functions within the building and the scale of movement.

(III) Other significant features inside the station building need also to reflect functional hierarchies. Passengers should be able to find their way from entrance to ticket hall, to platform, and to train without obstruction.

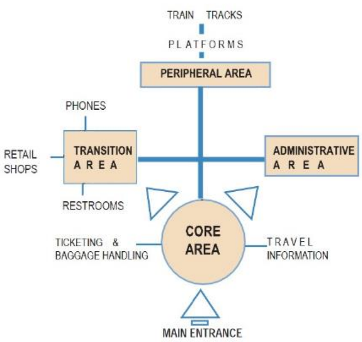

Fig. 3. Segregation of activities on a railway station

3.2. Railway station as a transportation node

Nodes are primarily created by the convergence of paths into a focal point. Paths are lines of travel used by people, and nodes therefore become areas of concentration and places where development starts. Transportation nodes are triggered by the convergence of more than one form of transportation into a point which creates an interchange where the different modes of transport can feed into each other. An example of how a transportation node or interchange works would be a case where people ride their bicycles from home to board a train at the station. Since there is a break in transportation from the bicycle to the train within a node, this creates a concentration of people in these areas.

Consequently, the concentration of people becomes an opportunity for the development of facilities such as shops, housing and offices that would be useful to the people at these nodes. The meeting point of different paths to form a transportation Node, can therefore initiate a commercial node.

Main Components of a transportation node:

Components that make up a transportation node differ with each specific situation and are based on the type of facilities that the node is planned for. For the purpose of this redevelopment design, the following elements that make up a node should be studied:

1) paths;
2) transportation station;
3) supporting facilities;
4) public open spaces.

3.3. Design approach

Issues related to Design of Railway Station ought to be studied from whole to part, acknowledging the implicit hierarchy of following three categories/orders, each with their own design considerations:

1. Transportation Infrastructure on And Around the Site - Describes the creation of Station volumes through large-scale engineering. Yard alignment, number and size of platforms, size and location of concourses, road networks dissipating the originating/terminating road traffic into the city, capacity of parking, traffic circulation, size of real estate at the station, etc. fall under this category and shall be designed at the primary stage.

2. Building Structure and its activities – Building components, such as detailing of concourse space, facilities for passengers, operational offices, staircases, escalators, elevators, passageways, entry, exits, roof, ceilings, walls, modal split of parking, type of real estate, development service ducts, etc. fall under this category and shall be designed at the secondary stage as per the profile of passengers using the Station;

3. Interiors - Subsidiary products and components layered over secondary elements to activate and animate stations fall under this category. This includes passenger information system, seating, lighting, advertising, handrails, etc. and shall be designed at the tertiary stage for bringing life and animation in the Station space.

3.4. Qualitative issues of design

Apart from the above stated quantitative issues the following aspects of station design too add to the quality of the space. Depending on the needs of the station, the design of these spaces has to also include supplementary functions; for instance, integration of light and structure, access for disabled people, and commercial development. It is possible to also see them as an expression of modern technology reflected in their daring structure and use of new materials.

4. AESTHETIC FACTOR STRUCTURAL ART OF A STATION

4.1. Structural art

Structural art is an art accomplished in the work of structure. Art forms have developed after Industrial Revolution in late 19 century along with the introduction of new materials – iron, structural steel, reinforced concrete, prestressed concrete, and later - structural glass, composite timber, other composites and fibre reinforced plastic. New materials allowed for new structural forms, such tensile structures, shells, grid shells, space frames, etc. These forms have determined the shape of engineering structures such bridges and buildings. Billing ton [5] has defined three goals of structural art – efficiency, economy, and elegance. These goals correspond with the need of the conservation of environment and accountability of funds while satisfying the need of aesthetics in public life and preservation of historical monuments. Structural art - as opposed to fine architecture which seeks the beauty of pleasing shapes independent of the structural skeleton of the building – is based on engineering structure that is fully visible and aesthetically pleasing in its own right being the prime source of the beauty of the building. [6]

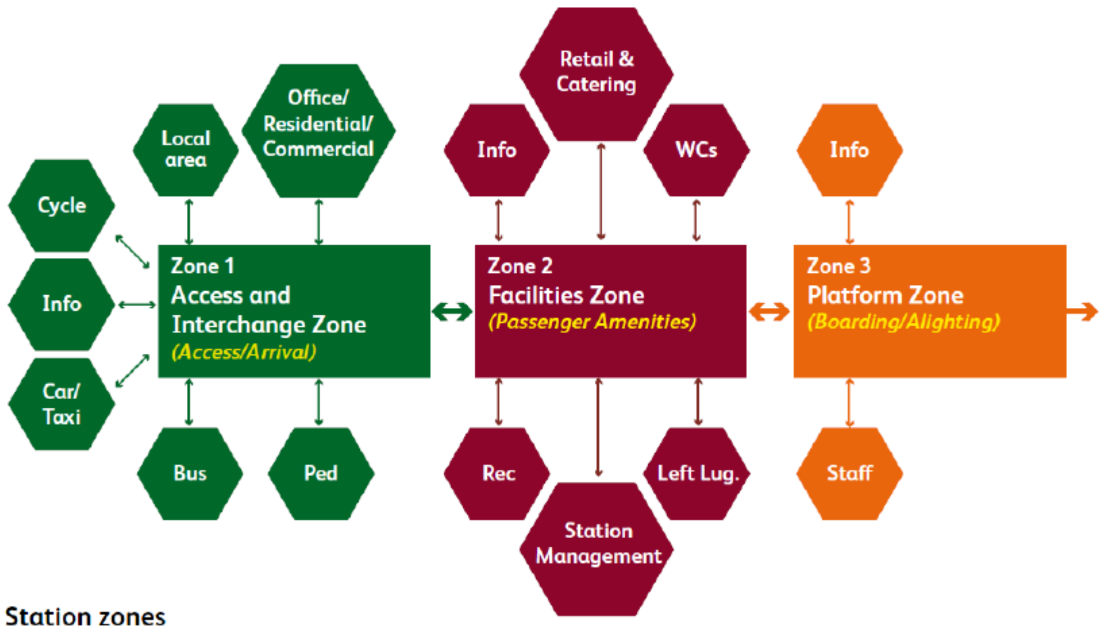

Fig. 4. Functional requirements of various zones of a railway station

4.2. Aesthetic factors of structural art

Structures and buildings to achieve structural art need to fulfill particular aesthetic criteria. Aesthetics of railways can be defined as a balance between exterior and interior of station, between building architecture, engineering structure and transportation function - in consideration of its planning, layout, details and context. Transportation functions needs to be sensitively distributed and clearly distinguished from other functions. Aesthetic station has to be clear, easy approachable and easy to understand, but at the same time it needs to provide a rich environment. Aesthetic factors of station design include objective qualities, such size and scale, proportion, form and shape, space, visual weight, light, texture, colour, composition, movement and rhythm, and details. In subjective response to built form, there are image-based elements related to design context, representation of the image of railways, of a brand of train operators, landmarks features, and to inclusion of artistic elements. Aesthetic factors are also related to distribution of commercial role of the station and treatment of advertisements.

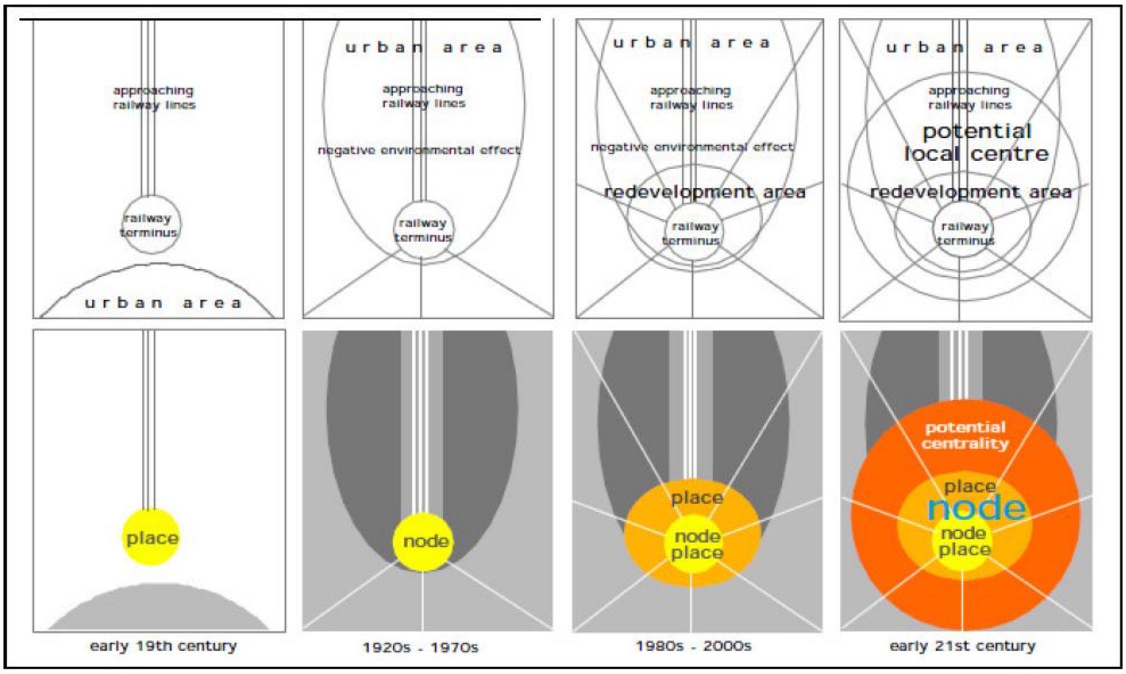

Fig. 5. The historical evolution of a railway termini

5. INTERNATIONAL STATIONS

This station type emerged in the past two decades after the introduction of high-speed trains connecting countries in Western Europe (Binney, 1995). The services of rail lines crossing countries' borders demanded particular facilities that differ from those of other stations. Many facilities have been borrowed from airports and adaptively applied to existing rail services. They include passport control, security checkpoints, and the different levels of departure and arrival pattern.

The Waterloo International Terminal in London is an excellent example of this type of station. It utilizes many of the characteristics and functions of airports and provides different levels for departing and arriving passengers. The extraordinary structure of a 1,300-foot-long shed added to the old structure and supported by steel trusses also strongly expresses the language of airport architecture. Train tracks are on the third level. The floors below the train shed are designed to handle 15 million passengers annually with terminal services providing easy access to and from the concourse located on the ground level (Binney, 1995) [13].

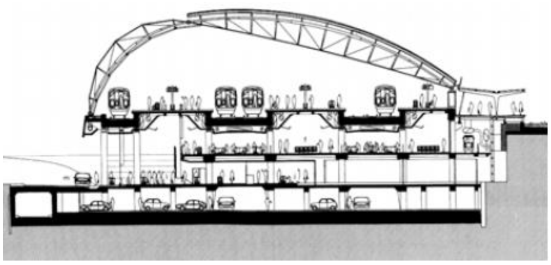

Fig. 6. Waterloo International Terminal, London Cross section showing different levels of departure and arrival. Source: Railway Stations: Planning, design and management, (p.252), 2000

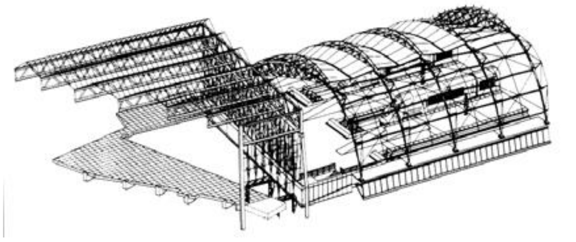

Fig. 7. Waterloo International Terminal, London Dissected Perspective showing platform level on the third floor and its roof

6. THE WAY FORWARD

Railways Stations today are much more than railway infrastructure, as they have the potential to become multimodal, multifunctional enterprises generating considerable commercial development within and well beyond their boundaries. The origins and functions of a modern metropolitan centre are located on and immediately around major Railway Station sites. Arterial spines and clusters of railway-linked businesses radiate outward from Railway Stations.

With this in perspective, there is enough scope to develop some of the existing major stations and/or even new ones as 'Strategic Hubs', which would act as pull factors for larger investments & commercial earnings and better branding / image enhancers in addition to creating significant employment and business opportunities. In short, such planned development/s of Railway Stations may lead to creation of a small, well-planned, self-contained & self-sustainable developments centred on the nucleus of Stations, which we would like to term as "Railopolis". The concept of developing several such 'Railopolises' would provide that much needed impetus to economic progress through supplemented Industrial, Commercial, Residential and Social infrastructure. [12]

Station building complexes need to be redeveloped in such a manner, that it not only de-congests and organizes the existing amenities and facilities, but also creates a landmark development model and a benchmark for other similar developments across the country. While it may not be possible to replicate the model in totality at all stations, it could set the parameters of development / redevelopment for other stations to follow. This would also ensure a sense of standardization and consistency in identity across the entire railway network.

7. CONCLUSION

As a general understanding rail has been the most economically viable mode of land transport, which makes it a relevant option for redevelopment. Apart from being affordable, rail is also a safer and much more efficient public transport system. The Stake holders of Ghana Railways have introduced Redevelopmental guidelines and plans for Railway sector, which is set to revive rail in Ghana and establish it as a major public transport system. Architecture and Engineering can play a role in changing the image of railway sector in Ghana, by creating architecture that better facilitates the function of the infrastructures, while ensuring that the environment is inviting to the targeted users.

Applying Design principles like the use of natural lighting, the intermodal concept in rail services, linkages and the legibility of the station circulation, as discussed in this study, are one of the main components to be applied in the creation of better station environments. The increasing numbers of passengers has resulted in the need for modern and rational designs of stations. The functions of station design are broadened. The form of the building becomes more complex. As a result, conventional stations are gradually replaced by station complexes, which do not serve travel alone. They are not just places where trains stop to collect and deposit passengers, but they become a gateway to and from communities.

Adopting a technical, strategic redevelopment plan to the railway stations across the country would categorically transform these national assets, make them a preferred commuter choice, provide a financial boost to the country's sustainable and environment friendly mode of transport and thus Enshrine our cardinals.

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РАЗРАБОТКА КОМПЬЮТЕРНОЙ ГИДРАДИНАМИЧЕСКОЙ МОДЕЛИ ТЕЧЕНИЯ ПОТОКА В КОВШОВОМ ВОДОЗАБОРЕ Г. БЕЛОЯРСКИЙ

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Согласно данным изысканий, выполненных в 2016 году, ковшовый водозабор г. Белоярский заносится наносам, загрязняется плавающим сором, водоприёмные оголовки забиваются шугой и водорослями. Главной задачей, в соответствии с СП 31.13330.2012, является обеспечение бесперебойной работы водозаборного сооружения. В работе приведены исследования вариантов усовершенствования ковшового водозабора г. Белоярский с использованием компьютерной модели течения потока». Целью исследований является усовершенствование ковшового водозабора с применением компьютерной гидродинамической модели течения потока.