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كلية الهندسة و تكنولوجيا المعلومات

Graduation Project Report II

{The Palestinian Race Track – Design for Safety and Convenience}

By

Ibrahim Abd-Allatif Khalid– 11715873

Oday Mahmoud Derbas – 11716283

Under the supervision of Dr. Khaled Al-Sahili

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DEDICATION

This project is dedicated to:

Our guide has always been with us and supported us when we needed him; Dr. Khaled Al Sahili.

For those, we all have, parents, family, relatives, friends, and colleagues.

The reason why we become what are we, and the source of all knowledge; The Civil Engineer Department.

To the first response, Arch. Iyad Sawalha, the supporter, and the professional engineer.

Then to everyone who stood with us in our project and our school profession.

ACKNOWLEDGEMENT

(لَئِنْ شَكَرْتُمْ لَأَزِيدَنَّكُمْ)

Given the specificity of our project as it delves into an area where we don't have much experience, so we needed the cooperation of many non-existing parties to provide expertise and advice to complete the project. We, therefore, have to express our wish for their presence shortly.

First of all, who's a great credit for completing the project, Dr. Khaled Al-Sahili, thank you for offering your time, energy, and experience, reviewing what we write, arranging our thoughts, and helping us in every step until the completion of the project.

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In closing, much thanks, gratitude, and love for our parents, the light in this life, who are our inspirations in all our lives, and their encouragement was always what motivates us to continue. For our friends, who were always with us supporting and encouraging us to give and achieve.

DISCLAIMER

This report was written by students at the Civil Engineering Department, Faculty of Engineering and Information Technology, An-Najah National University. It has not been altered or corrected, other than editorial corrections, as a result of the assessment and it may contain language as well as content errors. The views expressed in it together with any outcomes and recommendations are solely those of the students. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

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LIST OF ABBREVIATIONS

AASHTO: American Association of State Highways and Transportation Officials.

FIA: Federation International Automobile

Formula (F1, F2, F3, F4, F5, and F6):

Km: Kilometer

m^2: Square Meter

Min: Minutes.

PMSMF: Palestinian Motor Sport and Motorcycle Federation.

Sq. km: square kilometer

ASN: National Sporting Authorities (French)

ABSTRACT

The transportation sector is specialized in roads and highways, among others. Also, there are many sports cars on the street, which lead to speeding. This may cause accidents and loss of life in some cases. To prevent these things, a suitable place has to be available. Therefore, a race track circuit is provided for that, with the best racing criteria in light of local conditions.

Data were collected and analyzed. The Palestinian Motor Sport and Motorcycle Federation (PMSMF) was the main source of the local information. Searching for different criteria and specifications, and the best regulations, the Federation International Automobile (FIA) was used. Few tracks around the world were reviewed to make the optimum track in Palestine. The data were collected through various possible ways; visits, calls, emails, searching in the federation sites and asking the owners of local tracks or arenas, including race car drivers. Then the analysis begins, to understand the idea and the method of design. The available alternative was studied well to select the Jericho land with a1200 dunums, which is about 10km from al-Karama Bridge. Then the racetrack layouts were placed on the land area by the AutoCAD program. But an issue arises, which is the so many shapes to be studied. Therefore, many alternatives were made and studied, leading to an inner struggle. Of course, this was overcome by comparing all alternatives with each other and coming to a consensus. That was obvious in a project with freedom or allowance from a few points.

In the second phase of the graduation project, more details were explored. This starts with the design, then the length and width choices, as it has to be decided according to the land and the nearby roads. After that, there was the shape of the track, entrance, exit, parking lot, the VIP lots, and the building management. The design details include the superelevation and the curves, with the minimum radius. This is envisioned to be a carnival piece of land, as it is more fun and more interesting to visitors. For safety, there are three barriers to holding the car or any pieces to reach the audience, and to prevent any person of the audience to reach the track or even near it. In the case of accidents, there are allocations for an ambulance and firemen on the track. In addition, there are the referees' stands. A car could be damaged from the speeding turns or friction with other cars, so the pit lane was designed to provide for their safety. A detailed 3-D model was developed using the Race Track Builders and the Asseto Corsa programs showing race track details and saving time for the designer.

1 | INTRODUCTION

1.1 General Background

There are remains of the race track in civilizations, made for horses and carts, in London 1174 to 1780. In the late 19th and early 20th centuries, race tracks were designed to suit the nature of mechanical engines (Wikipedia, Race Track, 2022).

The first track was modified from horse-racing to automobiles in 1896 at Rhode Island, USA. The Indianapolis Motor Speedway was opened in 1909. In the early 1900s, motorcycle races were run on high, banked wooden race tracks named board tracks. During the 1920s, the speedway race was created to be a yearly event. After that, in the 70s, and 60s, people started using a new kind of karting vehicle in a close circular round (Wikipedia, Karting, 2022).

Each car circuit differs from the others according to the category of participating cars and the type of car, taking in consideration the type of activity they will be doing. For example, there is the speed racing, drifting and rally racing, each requires standards that must be met to ensure safety and the best experience for the riders.

There are major auto racing companies around the world, such as (ari helmet, Dover Downs Entertainment, Inc, Hulman & Company, NASCAR), such companies run races all around the world, here are some of the most famous races:

1. Monaco Grand Prix

The Formula One Monaco Grand Prix is held annually on the Circuit de Monaco since 1929. the Monaco Grand Prix is one of the most challenging courses on tour and happens during the last weekend of May.

2. Indianapolis 500

"Arguably the fastest racing series in America." Occurring during Memorial Day weekend, the inaugural race was held in 1911. This race consists of 200 laps counterclockwise around the Indianapolis Motor Speedway.

3. 24 Hours of Le Mans

Often called the "Grand Prix of Endurance and Efficiency" the 24 Hours of Le Mans was first held in 1923. This, along with the Indy 500 and Monaco Grand Prix makes up the Triple Crown of Motorsport. In order to keep the drivers safe, and due to its unique 24-hour competition, the rules and regulations have changed over the year

Looking outside the picture, such project gets conducted by major companies with expertise in sports, advertisement, marketing, car companies, engineering and contracting, making this type of sport as industry that includes huge investment and can bring enormous profit. around the world

Over the past years in the West Bank, it was noticed that there is more interest in motor sports, more people are attending races and more race events are being made. This came also along with car modifications as a habit, yards and spaces exist in the West Bank, where people have practiced this sport. These yards can be used but not called race tracks, and they are not designed as one. This creates the need to have a better space for people to practice this hobby.

Designing a racing circuit that matches the trend in Palestine is the goal of this project, making sure it's safe, enjoyable, and has a good level of competition for drivers. The project included a research process devoted to finding the basic principles that must be followed in designing a racing track according to clear international standards.

1.2 Study Area

Several criteria were set to follow through choosing the circuit location, and site investigation helped to cultivate thoughts and ideas about the arena. Choosing the arena location is a major factor in determining how the arena will look like, and what needs to be provided in the selected land.

These will be further investigated and evaluated in the subsequent sections of the report. The best alternatives were chosen be few ingredients like location, slopes, and area. Initial investigation showed that potential sites are to be in Jericho and Jenin areas. The two alternatives were discussed; a full comparison was made between the two sites in Methodology Chapter. The final location was chosen to be in Jericho.

1.3 Objectives of the Project

Through site investigation of several places in Palestine, the presence of spaces and car yards was noticed in Ramallah, Jericho, and Nablus, which tells that people were trying to create the place where they can practice this hobby. None of these yards or “racing tracks “was designed to fulfill the needs of people, and none was designed according to standards, which created the need for a dedicated place for this sport.

Therefore, there is a need to have a car racing circuit designed according to standards and specifications, to give a better racing experience for racers in much safer conditions, and for a variety of activities and that’s the major purpose of this project.

At first, the project was targeted mainly towards collecting information about racing circuits. Then the work shifted to conducting a full design for a racetrack in detail, along with needed structures and facilities. The design meets international standards for this industry and serves a racing event at its full potential. In addition, it includes presenting a 3-D model and a simulation of a car driving on the track.

1.4 Significance of the Project

The project gets the importance from several dimensions. First, it’s the safest place to feel free while drifting or doing the racing sport, as it is designed for that. Second, there is an investment potential for the investor, as there are growing interests in this field. Third, the nature of the land is close and near to the border, so it can be a place for holidays and weekends.

Furthermore, it will courage the young generation to become racers, drift drivers, and speed up safely.

1.5 Approach

The approach of this part of the project is to design a racetrack according to the FIA regulations and requirements. Using the data collected from the previous part and this part in the following process:

- Gathering information about Palestine's racing industry and the trend within it.
- Analyzing the data collected through various research methods
- A collection of information about racetracks around the world and the requirements for designing them.
- Analyzing all data collected and choosing the type of circuit to be designed, usually, the owner of the funding party is to be asked about what they want, and what's to be included in the circuit, this plays a major role in the planning, collecting of the data and analyzing it.
- Selecting a site for the study, and respecting the existence of archaeological sites, environment and humans to avoid harm and pollution.
- Planning and designing the circuit according to the FIA and ASSTHO requirements and standards.
- Creating a 3D model for the circuit using RTB. simulation for the track on AC.

1.6 Project Constraints

A lot of constraints faced the project during planning and design. In Palestine, the major racetracks were designed according to international standards by the FIA. The availability of such standards at the local level is lacking. This constraint forced the researchers to turn exclusively to online sources for their research. The availability of previous design documents for racetracks is a major constraint. There aren't any free documents for a racetrack project in the online sources, and the university library doesn't include any. Palestine isn't very familiar with this industry, the amount of expertise in this field is very limited, and the engineering offices in the country lack information about this industry. This made the references for information and calculations in this project mainly from online sources and based on reviewing tracks in other countries.

1.7 Report Structure

This report consists of six chapters as follows:

- **Chapter 1:**

  A general idea about the project, objectives, and nature.
- **Chapter 2:**

  Includes the methodology to be applied during this project. Furthermore, a detailed illustration of the formulas and methods will be used later in this report.
- **Chapter 3:**

  Embraces the literature review of Race Tracks cases and their shape, length, dimensions
- **Chapter 4:**
- The requirement, and criteria of the design. The used appendix, and resources to complete the design stage.
- **Chapter 5:**

  The data collected, relevant sources, and authorities. In addition to some definitions.
- **Chapter 6:**

  The outputs and results of the calculations from the design stage.
- **Chapter 7:**

  Conclusions and recommendations are set in this chapter.
- **Chapter 8:**

  References and Sources.

2 | METHODOLOGY

2.1 Project process

2.1.1 Data Collection

The project was based on two stages of the data collection. The first stage is to understand the Palestinian market and its needs in this regard. Then was defining trends in race events in the country. The second stage is picking standards to consider. The Federation International Automobile (FIA) regulations and requirements for the circuit were taken as the design criteria for this kind of sport. Taking into consideration that some standards from AASHTO can also be used for particular parts through the design process.

Data was collected from multiple sources. Through visiting racing event activities, competitors in drifting, and public go-karting sport. Interviews with some members in the PMSMF, and visiting the current "racetracks" were conducted. Also, the people are one of the most important factors affecting the motorsport facility. Their opinion is considered about the location and the preferred type of racing. The major source of information are the online websites, such sport is more popular, more developed outside of Palestine and the Arab world as whole.

2.1.2 Data Analysis

Roads are race tracks, but not all race tracks are roads. Data was collected to develop a circuit design, in accordance with the AASHTO specifications for roads and highways. Then the FIA came and made it comfortable to be considered as a racetrack.

A considerable portion of the consists of specifications provided by the FIA, these specifications were detailed and addressed to shorten the research process for anyone willing to continue this work.

Trip generation rate for the circuit was calculated from ice-skating rink in Provo, Utah studied for a trip generation rate, and San Diego Trip Generation Rate Manual. The study was completed by Brigham Young University, to predict the parking slots needed and the number of audience seats, which gave a good estimation for the land area dedicated for parking facilities. The affiliate buildings required serve the circuit were determined based on the expected number of participants.

Understanding how each race vary in accordance to the circuit grade and the vehicle racing is crucial, such information sets up the process to design. knowing the design car leads to knowing the possible races the car participates in, thus the grade of the circuit is determined, in analyzing the data such process was explained how each lead to the other

Through the research, it was important to know how many people (circuit staff, spectators, drivers, press) can be in the circuit, and with what they traveled (bus, taxi, private car). This allows the engineer to translate these numbers to transportation concept. These numbers after analyzing were translated to parking spaces and modifications to the road on circuit

2.1.3 Design process

The following steps were followed in this project:

1. Selecting a site for the study, and respecting the existence of archaeological and environmental sites to avoid harm and pollution.
2. Data analysis taking into consideration the trend in the racing industry in Palestine. The type of race that will be held tells the kind of cars that will race. For example, selecting the type of car, and determining the grade of the circuit.
3. The Grade of the circuit identifies values related to the track length, the minimum length, and the maximum length of the track can be determined.
4. Drawing a layout for the track is a fundamental and first step in the planning stage, taking into consideration the various kinds of curves to be included. The inner service roads, structures, and infrastructures affect the shape of the circuit and should be taken into consideration.
5. Choosing the locations of grandstands, main structures, parking area, an advertisement, and calculating the approximate area required for them.
6. Designing the corners and estimating the run-off areas.
7. Simulation for the track using an Asset Corsa game engine, and recording speed values according to parameters.

8. Constructing a racing line using numerical methods, and comparing speed values to the simulator results.

2.2 Obligatory Circuit Dossier

Getting the FIA approval for a circuit requires a fully detailed submission of the project documents and inspection after the construction of the circuit.

The circuit dossier should include information as follows (FIA, Appendix O, 2021).

1. cover letter introducing the circuit project.
2. Circuit layout to scale 1:2000 (minimum), with an indication of orientation, pit entry, and exit roads, turn numbers, race direction, buildings, installations, access roads, spectator areas, safety barriers, (walls/guardrails), debris fencing, attenuation devices, race control, timing room, pit buildings and garage area, paddock and ParcFermé, ambulances, medical center, firefighting vehicles, medical intervention vehicles, marshal posts, light panels (if applicable), video surveillance cameras and circuit floodlighting (if applicable). The drawing should also indicate the distance measured in 50m increments from the start line along the track center-line in the driving direction.
3. Construction specifications. For transportation like curbstone, and guardrails. A structure like concrete walls, nonpermanent concrete walls, energy dissipating devices, pit wall debris fences, opening barriers including hinges and locking devices, debris fences, spectator control fences, drainage, manhole covers, and methods of fixation.
4. Location of start line and control line.
5. The estimated location of pit entry and pit exit speed limit lines, Safety Car-line 1 (SC1) and Safety Car-line 2 (SC2), the precise location of these lines is to be confirmed with the inspector on-site.
6. The precise GPS latitude and longitude coordinates in decimal degrees of the intersection point between the track centerline and the control line.
7. Plan of pits and paddock area and medical center to scale 1:500 minimum.

8. Detailed plan of all buildings (including medical center and helipad), to scale 1:200 minimum.
9. Profile of the 3D track center-line, track edges, and the first line of protection, to scale 1:2000 (length)/1:200 (altitude) minimum.
10. Cross-sections of track and lateral space (for at least 10m, on each side from the track edge), at the start line, the center of principal corners, points of minimum and maximum width of the track, bridges, and other singular points, to scale 1:200 minimum.
11. Questionnaire provided by the FIA concerning the medical center and the referral hospital(s), duly completed. This questionnaire is available at www.fia.com/circuit-safety (FIA, 2019).

Circuit dossiers should be submitted electronically. The electronic plans shall comply with the FIA circuit drawing standard. Autocross and rally-cross circuits are exempt from this requirement. They should be revised and sent to the FIA regularly. The course has been modified and will be an essential reference for FIA inspections and the issuing of circuit licenses (FIA, FIA regulations, 2019).

Projects for new circuits or major alterations to existing circuits should be forwarded, through the ASN, to the Secretary of the Commission for initial technical comment.

These requirements pass the scope of the project, as the first step to introducing this knowledge. In this project, the outcomes are a 3-D model of the circuit using Race Track Builder (RTB) along with a detailed 2-D view for the track using AutoCAD software, and a simulation for the track using Asseto Corsa, and sections for the track are also prepared.

2.3 Specifications and Criteria

Design guidelines of the American Association of State Highway and Transportation Officials (AASHTO, 2011) will be followed to design the requirements of the entrance road and the bus lane. This includes the selection of the design speed, grade, elements of the road, alignments, and the requirements of pavement and drainage design. Furthermore, marking, guidelines will be followed to design the requirements of the track.

The FIA is: Fédération Internationale de l'Automobile or International Automobile Federation is an association formed in 1904 to represent the interests of motoring organizations and motor car users. To the general public, the FIA is mostly known as the governing body for many autos racing events, such as the well-known Formula One. The FIA also promotes road safety around the world. (FIA, Wikipedia, 2022)

In this project, the FIA's standards were followed, the FIA has several releases, it is updated every year, and the releases are reliable for two years. A variety of H, M, and O releases are included in the scope of this project, as will be detailed later.

2.4 Location Alternative

For best design, an over look has been toked for all of West Bank lands. From north to south and from east to west, just to have an idea of available region. From 5860 km², two spots were found appropriate. First one in Jericho, at the middle of the West Bank. Second one is in Jenin, the far north of the West Bank. Two alternative sites were investigated. These are presented in (Table 2.1). The sites were evaluated based on the following criteria.

1- Terrains: it was recognized that we need a level terrain to make a reasonable design to be implemented, and to have a low-cost excavation work.

2- Location in the West Bank: it should not be far from people from different areas; preferably in the middle region of the West Bank.

3- Climate: rain can lower the friction between the car wheels and the asphalt, which may cause the cars to crash, or not to perform as well. Dry weather can help in a longer season duration, and would facilitate the scheduling of events.

4- Accessibility to nearby road network: this is a very important to determine, the number of audiences is huge with high accessibility, which requires to take in consideration in design phase, and also, estimating the revenue the facility can make.

5- The location has to be far from residential areas, due to gas emissions and noise the race event has.

In (Table 2.1) as shown, a simple comparison of the two lands were done. Multiple points were important to consider at choosing a location, such as the accessibility and near main road network. Other viewing point were the large area to have a flexibility for the design and layout. According to the table, Jericho was much better from Jenin. That's due to the nature of the land, weather, and under surface soil type. In (Figures 2.1 and 2.2) of the alternatives, they show the difference and reasons of choosing one over another (Government, 2021).

Table 2.1: Location Alternative Comparizone

Poor	Accepted	Perfect
[redacted]		
Location	**Jericho**	**Jenin**
Area m²	409.000	810.000
Elevations	-220 _ -244	318 _ 360
Land Currently use	Non – used	Farming and Harvesting value
Temperature variation	48-10	40-6
Soil type	Sand	Clay
Whether case	Scattered light rain	Successive heavy rain
Accessibility	Very good	good
Region Classification	C, low agricultural	A, High agricultural

Figure 2.1: Location 1 Photo

Figure 2.2: Location 2 Photo

About 640m distance is the distance between circuit and the nearest urban area as Figure 2.3 shows.

Figure 2.3: Topography Photo 1

The chosen location is an active spot nearby Al-Karama Bridge Figure 2.4.

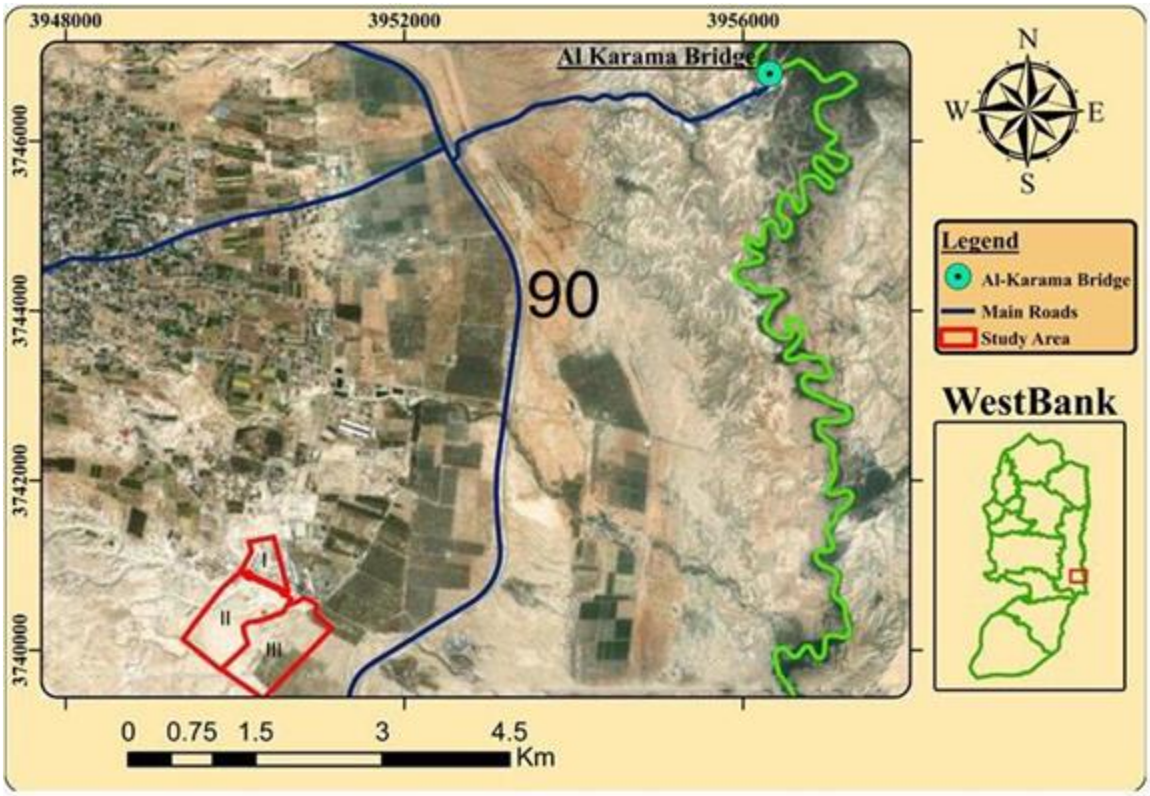

Figure 2.4: Topography Photo 2

3 | LITERATURE REVIEW

3.1 Racing Circuits and Their Geometric Design Characteristics

This research was submitted to the FIA to show the capability of Croatia to host an international racing event for Formula 1 and to submit a conceptual design for the hosting track. It shows the basic understanding of the conceptual design of racetracks and the major components of circuits, showing real examples of existing circuits licensed by the FIA. The details are presented in Tables 3.1 and 3.2 (Barišić, 2019).

Table 3.1: Circuits Dimensions for Croatia Study (Barišić, 2019)

	FIA regulation	FIM regulation
License grade	1, 2, 3, 4, 6	A, B, C, D, E
Maximum straight section length	2 km	1 km
Circuit length	7 km	4.2 – 4.5 km
Track width	12 m	12 m
Starting grid width	15 m	14 m
Track width change gradient	1:20	1:20
Transversal inclination along straights	1.5 % – 3 %	1.5 % – 3 %
Transversal inclination in corners	10 %	5 %
Track verges width	1 m – 5 m	2 m
Run-off area slope	3 % downwards; 25 % upwards	3 % downwards; 10 % upwards
Distance to first corner	250 m	250 m

Table 3.2: Racing Circuits and Geometric Characteristics for Croatia Study (Barišić, 2019)

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Racing circuits and their geometric design characteristics

Circuit	Yas Marina	Bahrain BIC	Barcelona	Monza	Interlagos	Korea	Monaco	Sochi	Spa	Suzuka
Lap length [km]	5.554	5.411	4.655	5.793	4.309	5.615	3.337	5.848	7.004	5.807
Race laps	55	57	66	53	71	55	78	53	44	53
Race distance [km]	305.355	308.238	307.104	306.72	305.909	308.96	290.286	309.745	308.052	307.471
Turns	21	15	16	11	15	18	19	18	19	18
Maximum speed [km/h]	339	321	317	337	323	313	290	343	320	328
Distance to turn one [m]	305	265	730	638	334	250	111	1029.5	271	405
Full throttle [%]	59	66	56	76	50	62	43	50	70	66
Longest flat-out section [m]	1223	1205	1310	1520	1394	1125	669	1073	2015	994

Table 2 Characteristics of existing racing circuits [10]

In Table 3.1, the document showcases the main aspects that set characteristics for the conceptual design for the track itself without its surroundings. These regulations and standards refer to Appendix O released by the FIA (FIA, Appendix O, 2021).

Table 3.2 shows the characteristics of current racetracks; these numbers indicate the design values this project will have.

Figure 3.1 compares the number of inhabitants for international FIA licensed racing circuits of some European countries according to the data on population. It can be seen that the population of Croatia (4,255,374 inhabitants) is well suited to the ratio of population and the number of the racing circuit in other countries. Hence, Croatia can optimally accompany one internationally licensed racing circuit (Barišić, 2019).

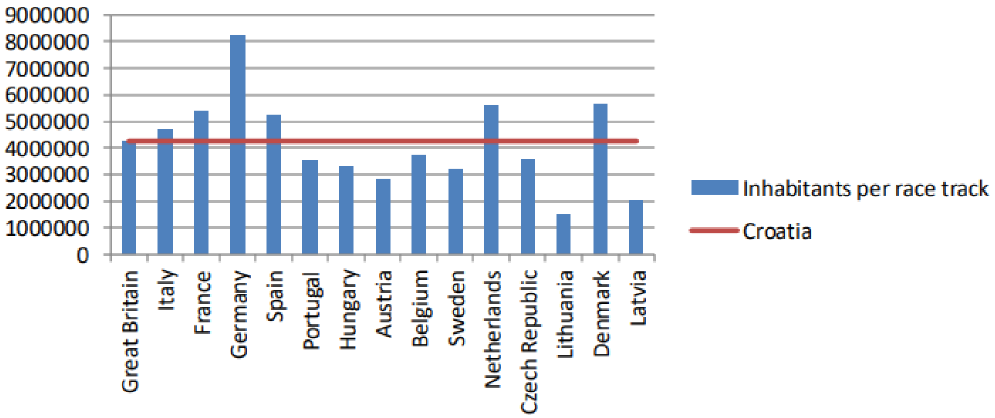


Figure 3.1: Circuits Licensed in European Countries (source: Barišić, 2019)

3.2 Racing Circuits as a Project Study

The document shows numbers of the size of investments in this industry and visibility studies that should be made before beginning such a project. Such studies will focus on the popularity of the sport in the country, and predict the attendance for these races in the region (Barišić, 2019).

Investing in the construction of racetracks represents a major project even for countries larger than the Republic of Croatia. The cost of such investments must be justified and should be sustainable for a wider community and not just a narrow circle of users of such facilities. When designing and constructing, detailed analysis, estimation, and optimization with cost-benefit analysis have to be done, which can only be achieved by a good engineering approach to the project. Unlike road design, access to the design of track lanes is unclear and undefined and can be reduced by adapting access to public roads. However, in an environment where human lives can be vulnerable, it must not only be good enough, that is unacceptable (Barišić, 2019).

In the process of developing design approaches, test courses and driving simulations should be included to carry out multi-level analysis ensuring maximum driver safety on the track. Driver's safety in such extreme conditions is at the highest level that must be met concerning the set criteria (the fastest vehicle to use the track and its characteristics) (Barišić, 2019).

Personal cars are increasingly becoming autonomous vehicles, and the need to control them by humans will shortly. With this, the need to enjoy driving action itself will be shifted to racing tracks that are currently not sufficient to address future needs. This fact opens the possibility of developing a new market that would be focused on small (local or regional) competitions as well as open-door days on racing tracks. Additionally, along with the infrastructure that follows such a route, the possibility of inviting a variety of companies such as automobile mechanics, rent-a-car companies, retail outlets, gas stations and electric fillers, and catering establishments would open. When there are no cars and motorcycles, cyclists and runners could take the track, as it would be possible to organize concerts and similar large open-air events on the premises (Barišić, 2019).

4 | FIA REGULATIONS AND REQUIREMENTS

Creating a great racing circuit depends on the track layout and on the level of competition the track delivers. a racing circuit isn't about some straights connected with corners, it's very far from being like that, throughout this project, the concept of planning and designing a racing track will be submitted, with its essential needed measures, requirements, and regulations according to the FIA and AASHTO (MOTOR, 2018).

4.1 Planning Stage

There are several factors that affect the final shape of the racing circuit and its layout, such as, protective measures, needed level of competition, circuit buildings and insulations, trackside advertising, and structures and standards.

4.1.1 A NEW CIRCUIT, CONSIDERATIONS

1. Protective measures for a racing circuit: The FIA regulation for motorsports puts safety as its priority, the FIA releases documents that insures derives, spectators and circuit staff safety. the international code by the FIA restricts and well defines some rules e.g., drainage, and for some e.g. track shape, its left for the designer to take the choice with a space of freedom to be creative, although, the FIA still gives its recommendations and any changes the FIA thinks they are essential to be done during the design stage (FIA, Appendix O, 2021) (MOTOR, 2018).

2. The categories need to determine the protective measures for are: spectators, drivers, race officials and service personnel during competitions. The characteristics of the course should be also taken in consideration, such as, typography, layout and profile, racing trajectories, and adjacent areas (FIA, Appendix O, 2021) (WTF1, n.d.).

3. To provide smooth driving, conditions to regain control of the car and absorb its momentum energy, various deceleration systems, energy-dissipating and stopping barriers maybe installed to constitute a first line of protection. Such insulations

include: grass or sealed surface run-off areas, deceleration beds filled with appropriate aggregate, stopping barriers, energy-absorbing barriers or a combination of these measures (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

4. As a general concept, speed and impact angel affect the type of protective to be installed. If the estimated impact angel is low continuous, vertical barriers are to be installed. If a high impact angel is estimated, energy-dissipating devices and/or stopping barriers should be used. Where provided, run-off areas will be principally situated on the exterior of the corners and may typically have depths from around 30 m to 100 m (FIA, Appendix O, 2021).
5. Around a corner, the car is likely to fly off the road and hit a barrier at a steep angel as in Figure 4.1 (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

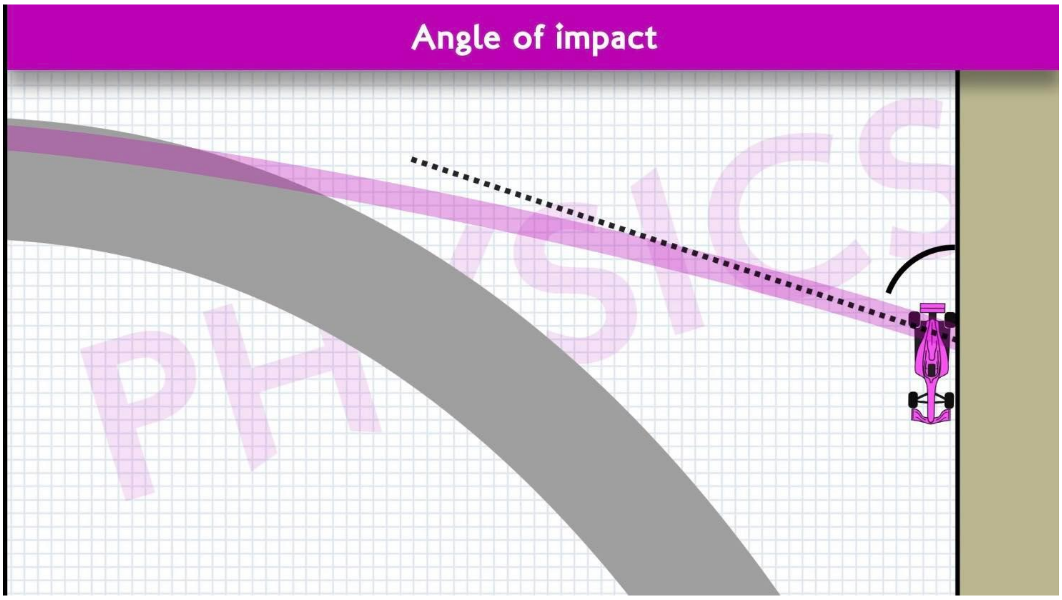


Figure 4.1: Angle is a Trajectory, Not Car-Pointing Angle

On a straight section, a car is more likely to hit at a shallow angle as shown in Figure 4.2 (FIA, Appendix O, 2021).

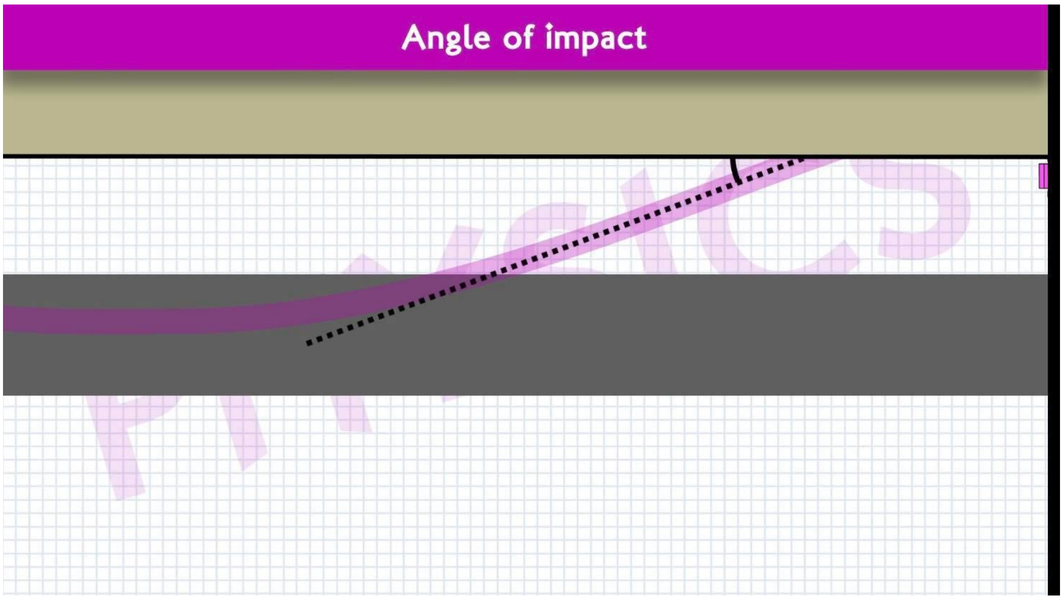


Figure 4.2: Straight Line Trajectory

In both cases, how much speed is the car carrying perpendicular to the barrier, car energy gets carried by 2 components, parallel and perpendicular to the barrier as in Figure 4.3 (FIA, Appendix O, 2021).

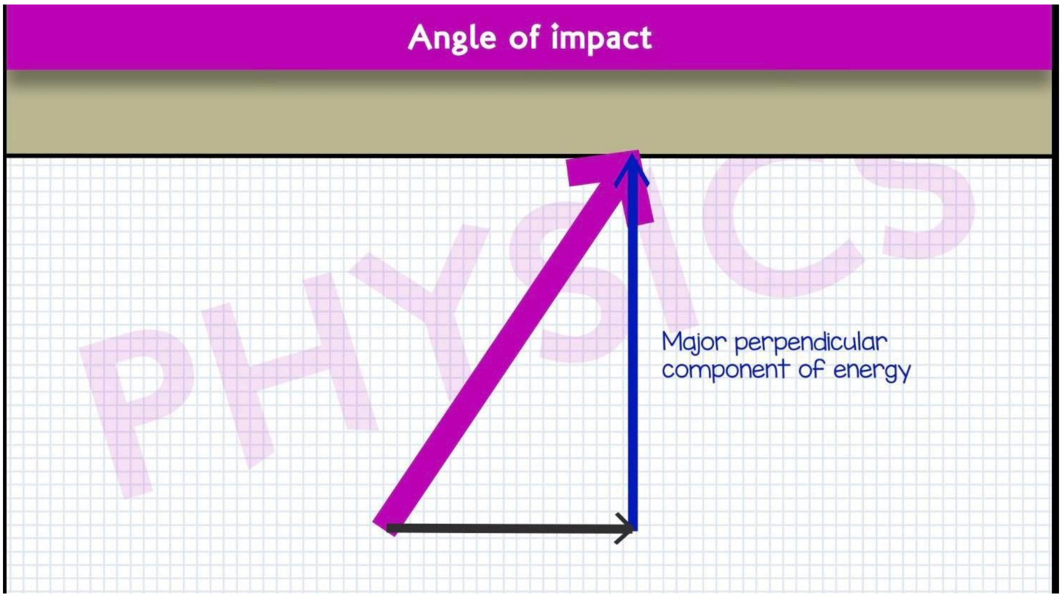


Figure 4.3: The Steep Crash Perpendicular Trajectory

In a steep crash angle, most of the speed will be carried perpendicular to the barrier. In a shallow angle, as Figure 4.4 shows, most of the energy is carried parallel to the barrier with only small component into the barrier (CHAINBEARF1, n.d.).

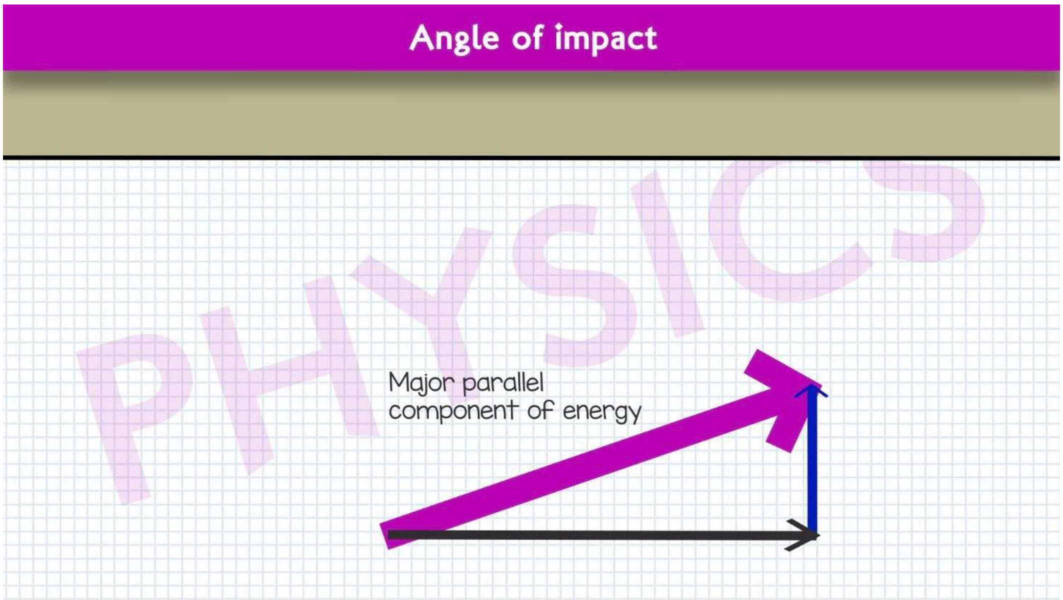


Figure 4.4: The Steep Crash Parallel Trajectory

In such a case, the energy needs to be absorbed in parallel direction by minimizing the deformation of barriers, slow the car down with fiction by forcing it to slide along the wall, Figure 4.5.

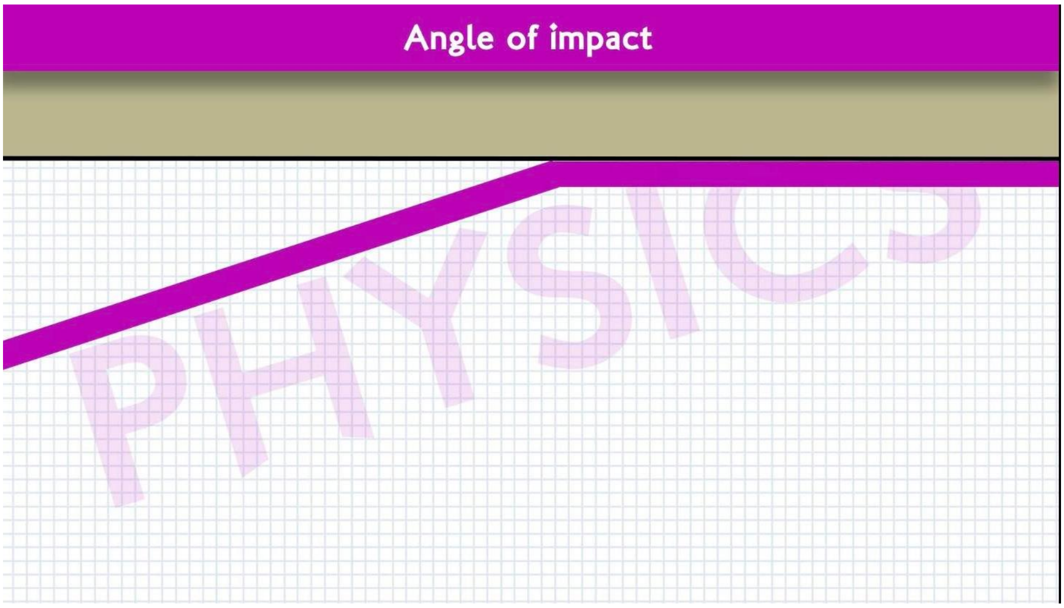


Figure 4.5: Angle of Impact

Along straights, increasing the chances of shallow crash angle by bringing the walls closer to the track edge, taking in mind that a car lost control, needs time to travel through a curve that will transfer its trajectory from parallel to perpendicular (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

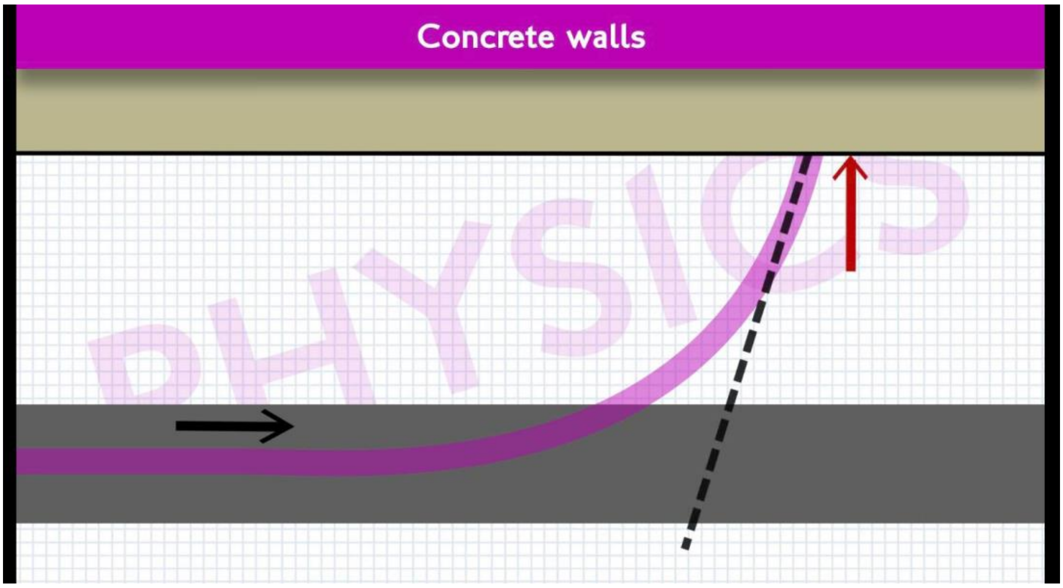


Figure 4.6: Concrete walls

4.1.2 Barriers clearness of the track:

Bringing the barrier closer to the track edges serves well in:

There isn't much area to use run - offs (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

Around starting straight bringing the grandstand closer might be a need.

Concrete walls Figure 4.7, Guardrails Figure 4.8, tire barriers Figure 4.9 and tecpro barriers Figure 4.10, all those are used in shallow impact angle case to absorb car energy.

Figure 4.7: Concrete walls

Figure 4.8: Guardrails

Figure 4.9: tire barriers

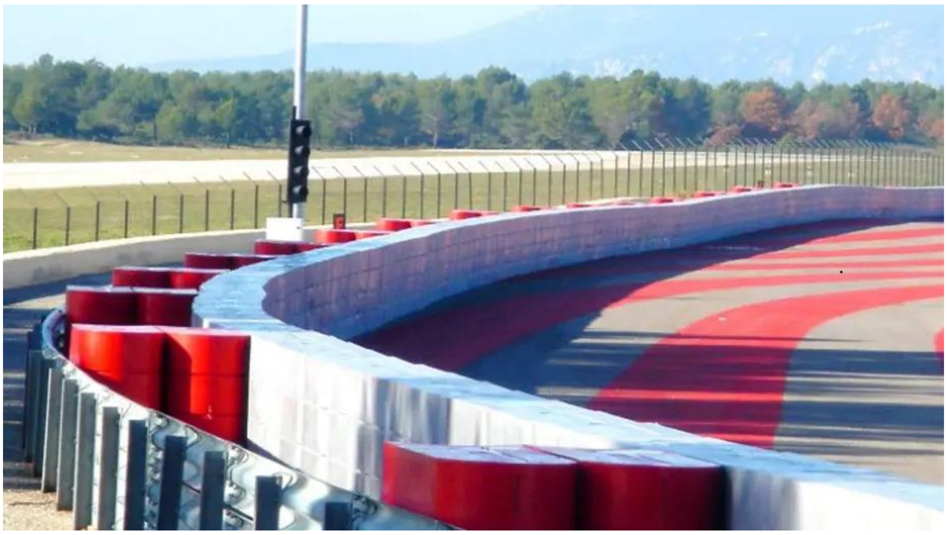


Figure 4.10: Techpro barriers

Protecting the public areas are also to be taken in consideration; supplementary measures should be placed at the same level as or higher than the track edge, may be required (FIA, Appendix O, 2021).

4.2 Location

The location of a racing circuit plays a major role in the planning stage. The location of the circuit should be far from residential areas, due to its noise and emissions. The circuit has the ability to be extended for future projects such as training circuit (WTF1, n.d.) (Barišić, 2019).

Figure 4.11: Topography to the Land and Near Urban Area

The Figure 4.11 shows that the circuit location is 640 m from the nearest urban area. The location also affects how the track will look like, the area, the terrains are key, trying to adopt the terrains is recommended which reduces the construction cost.

4.3 Conceptual Design Considerations

4.3.1The Length Determination

The plan: the FIA specifies the minimum length based on the duration of an international racing event and the recommended maximum length based on experience. The length of racing circuits gets measured by the center line of the track.

The minimum length for an international racing event based on the following table (4.1):

Table 4.1: Minimum Circuit Length

Cars	Minimum circuit length based on event duration (km)		
	2h45min	6h	12h
F3	2.0	-	-
Touring car	3	3.2	4
GT	3.5	3.7	4.7
F1	3.5	-	-
Sports car	3.5	3.7	4.7

- 7 km is the maximum circuit length recommended by the FIA for any new circuits; also putting in consideration that a straight section mustn't accede 2 km in length.
- The following points summarizes the back thoughts of limiting the circuit length straight section lengths:
  - ✓ Exceeding the 7 km of racing circuit makes it less safe, expensive, more complicated, and incredibly long. More length requires more marshal posts, cameras, and timing equipment's all the way down across the circuit. Medical intervention in a serious crash event on far end will be more difficult because it has to travel all the way around the circuit until it reaches the crash point. Although this problem can be tempered by putting emergency inroads inside the track that closed for the public during active sessions, or by distributing medical cars around the circuit in various intervals (CHAINBEARF1, n.d.).
  - ✓ Also, with the track being too long, it seems to be too sparse, with spectators seeing the cars less frequently compared if the track was shorter with shorter lap times (CHAINBEARF1, n.d.).
  - ✓ For Touring cars, having a track less than 3 km will result of the track being crowded and cars will constantly start tripping each other (FIA, Appendix O, 2021).

4.3.2 The Width Determination

Circuit Width: For any new racing circuit the foreseen width should be at least 12 m; the change in width should be done as smooth as possible. The FIA specifies that the change in width shouldn't accede the rate of 1/20 m as Figures 4.11 and 4.12 show.

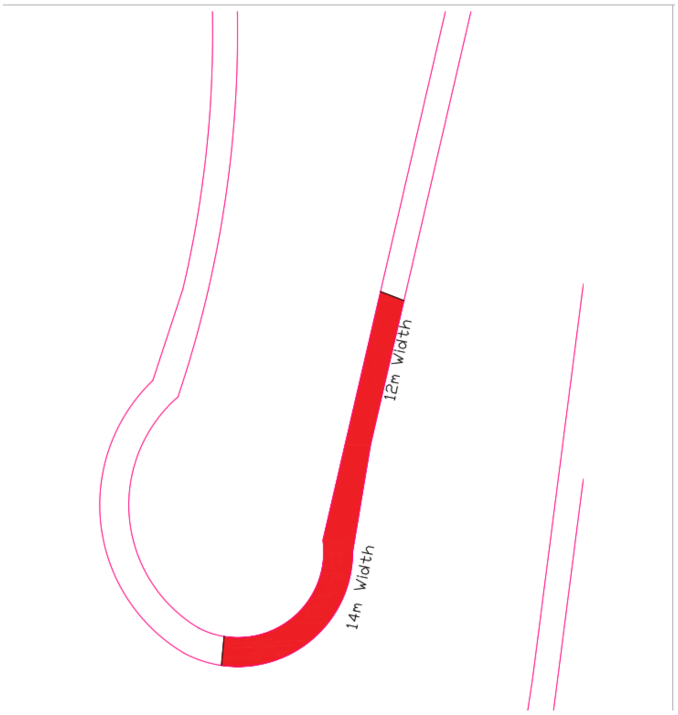


Figure 4.12: Minimum Width

- The starting grid is specified differently, the minimum width should be at least 15 m Figure 4.12, and it should be obtained until the exit of the first corner (FIA, Appendix O, 2021).

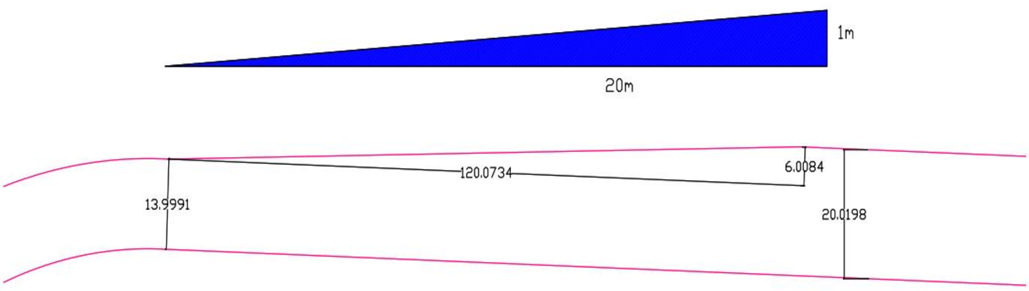


Figure 4.13: The Rate of Taper

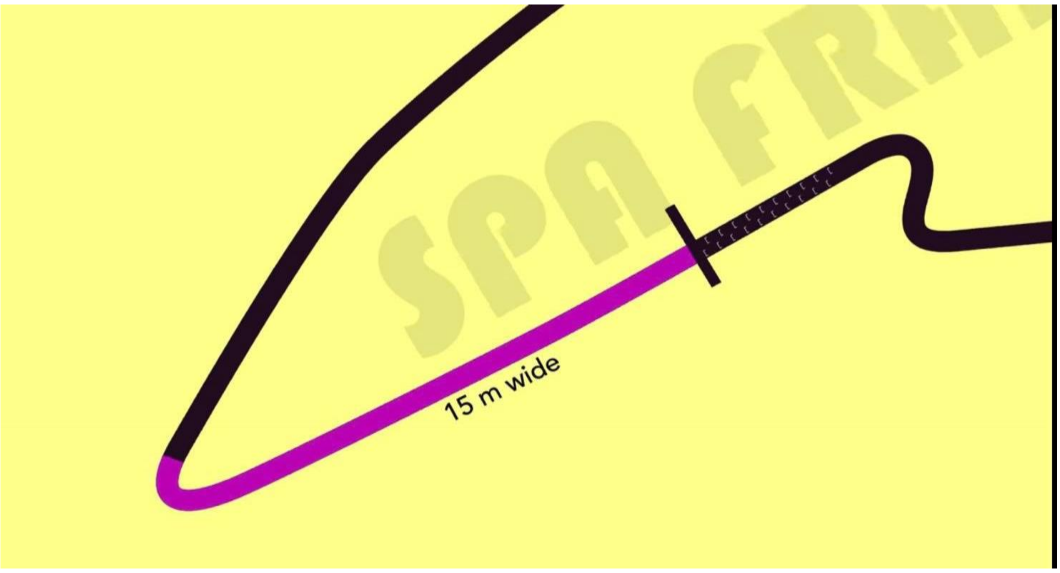


Figure 4.14: Minimum width of Start Line

4.3.3 Transversal inclination & drainage

- The grid should line in gradient not steeper than 1.1 degrees, so the drivers don't have to hold the car at the clutch biting point or pull the hand break to keep the car stable, as Figure 4.15 shows (FIA, Appendix O, 2021).

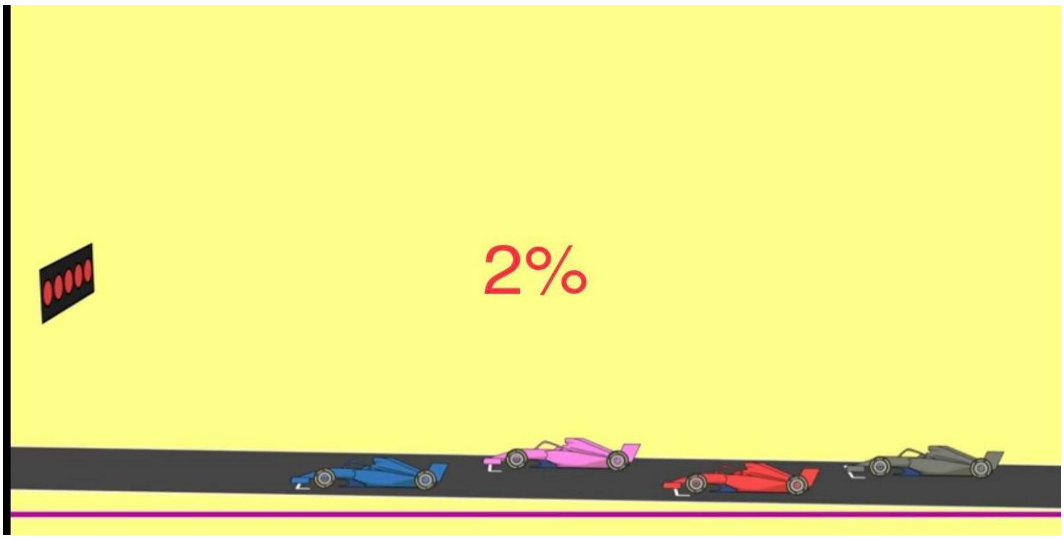


Figure 4.15: The Longitudinal Slope

- In straights, the transversal inclination for drainage purposes strictly requires to have limited chamber, that's is the gradient across the width lies between 0.9 and 1.7 degrees, measured from edge to edge or from center line to the edge. This is to ensure drains from the middle of the track and it doesn't pool or puddle to create dangerous areas of aquaplaning, also not being too absurdly chambered in a way the cars sit on the track properly or struggle to drive. Figure 4.16 shows the principles (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

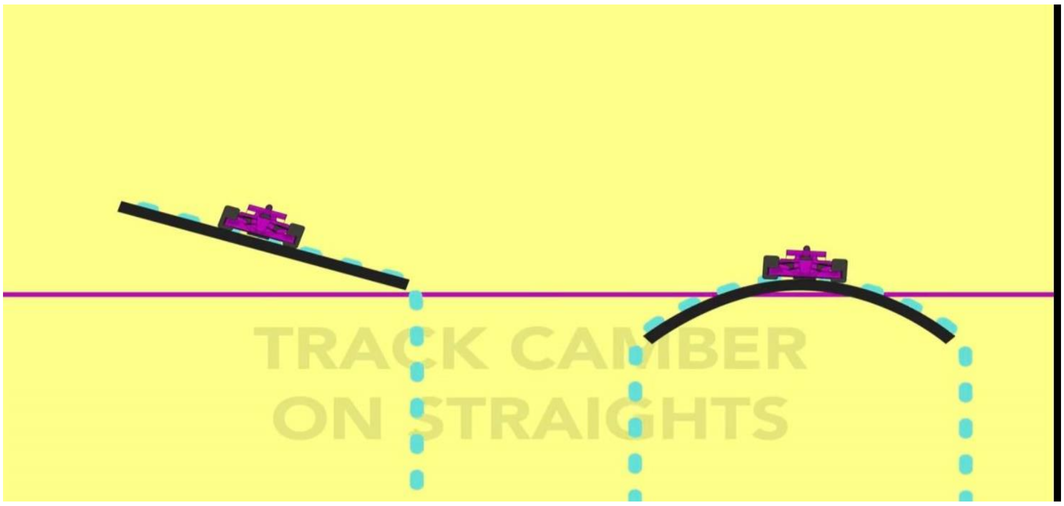


Figure 4.16: Drainage Banking

- In curves, the banking on chamber shouldn’t exceed 5.7 degrees Figure 4.15, measured downwards from the outside to the inside of the track. The adverse inclination out chamber Figures 4.17 and 4.18 is to be done under special circumstances and to be spectated by the FIA. The chamber helps the driver to round the corner, and it pulls the car to the bend by shifting some of the weight to point inside. The adverse inclination does completely the opposite, in which it pulls the car outside the bend, encouraging instability in corners (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

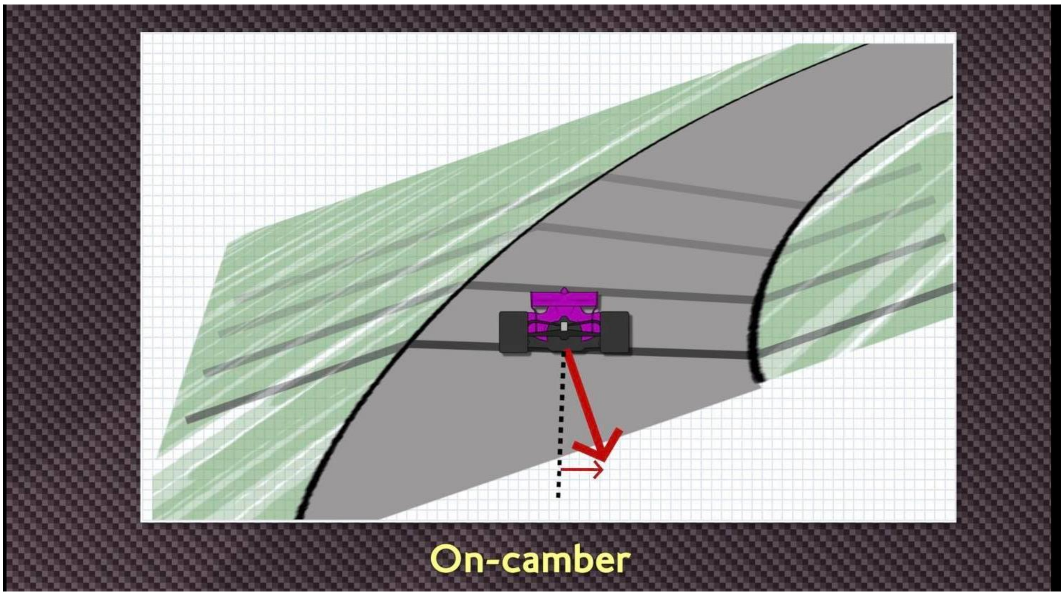


Figure 4.17: Direction of Force On-Chamber

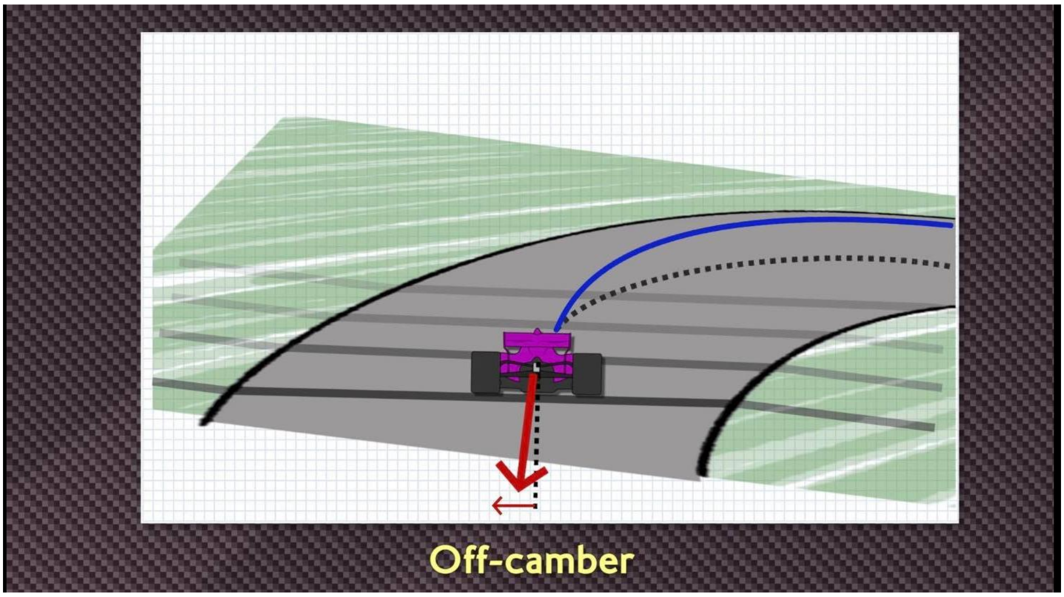


Figure 4.18: Direction of Force Off-Chamber

- Longitudinal profile: the gradient from start /finish shouldn't exceed 2%, and it must be done using vertical radii, ensuring its suitable for the racing cars performance. In general, in high-speed breaking sections and curves gradient should be avoided as much as possible (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

4.3.4 TRACK EDGES, VERGES AND RUN-OFF AREAS

The track itself should be permanently marked, a minimum 10 cm wide line (painted with anti-skid paint) should be applied of the whole length of the circuit on both sides, followed by verge between 1-5 m wide that follows the profile of the track surface with even surface with the track. Thus, the level or the slope of the track doesn't change suddenly (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

Kerbs are safety installations added at the side of the track. Kerbs helps to define the edges of the track. Also, kerbs are there to restrict drivers from using runoff areas to cross corners with ease, some corners are designed to be hard. Therefore, Kerbs is needed from competition view Figure 4.19 (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

Figure 4.19: Kerbs

Run off areas lie between the verge and the first line of protection. Any run off area has to follow the verge smoothly and not to slope more than 14 degrees upwards or 1.7 degrees downwards (FIA, Appendix O, 2021).

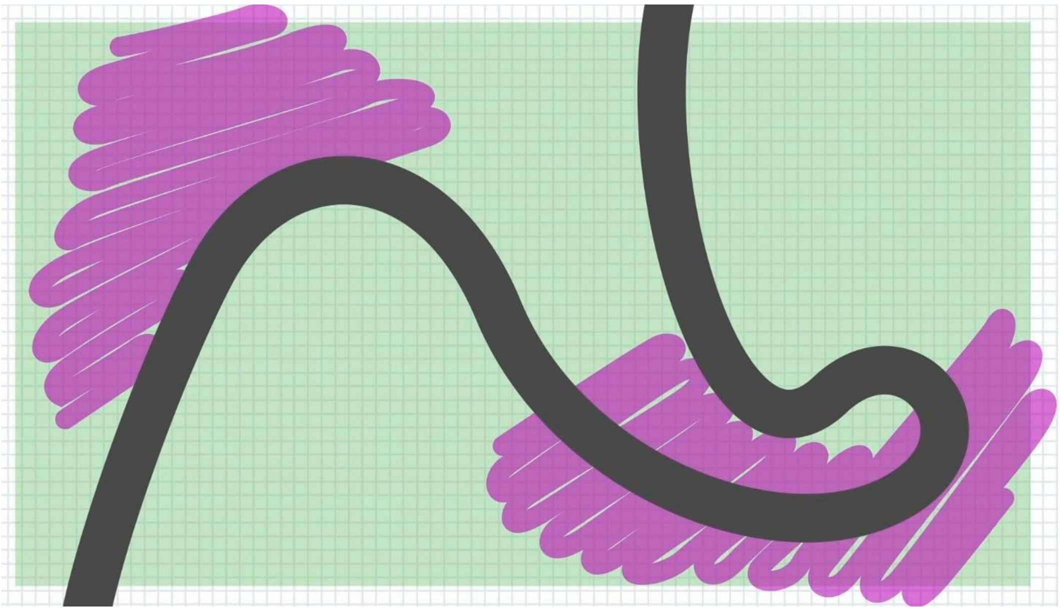


Figure 4.20: Runoff Area 1

Figure 4.21: Runoff Area 2

Figure 4.22: Sausage Kerbs

Figure 4.23: Track Side Marking

As discussed before, impact angle prediction helps in controlling accidents, and provide insulations the helps the driver to regain control of the car by absorbing energy through barriers. Run–off areas are another part of controlling the accidents and absorbing the car energy (CHAINBEARF1, n.d.).

The point of a Run–off area is to increase the distance between the track and anything the car might hit at a high speed, this distance helps the car in slowing down, so it hits the barrier with a low speed, or it doesn't hit it at all. the figures below explain the process (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

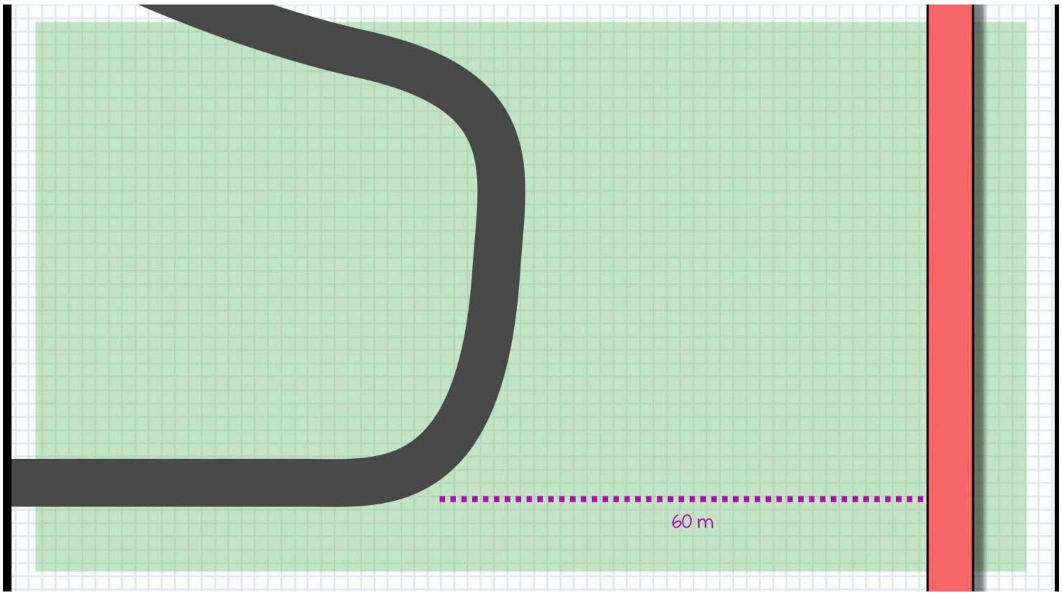


Figure 4.24: Runoff Deep Length 1

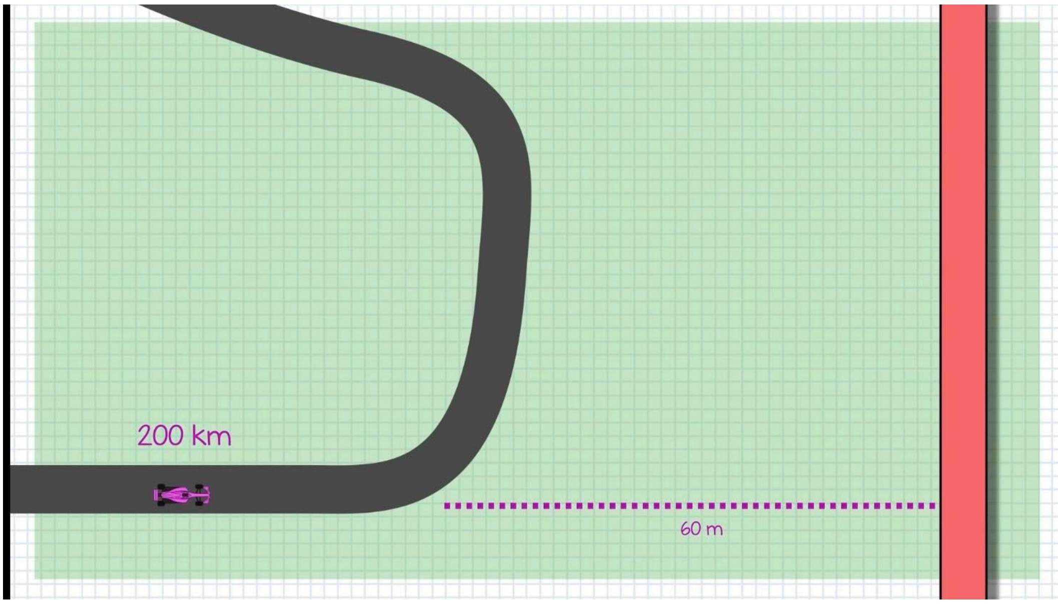


Figure 4.25: Runoff Deep Length 2

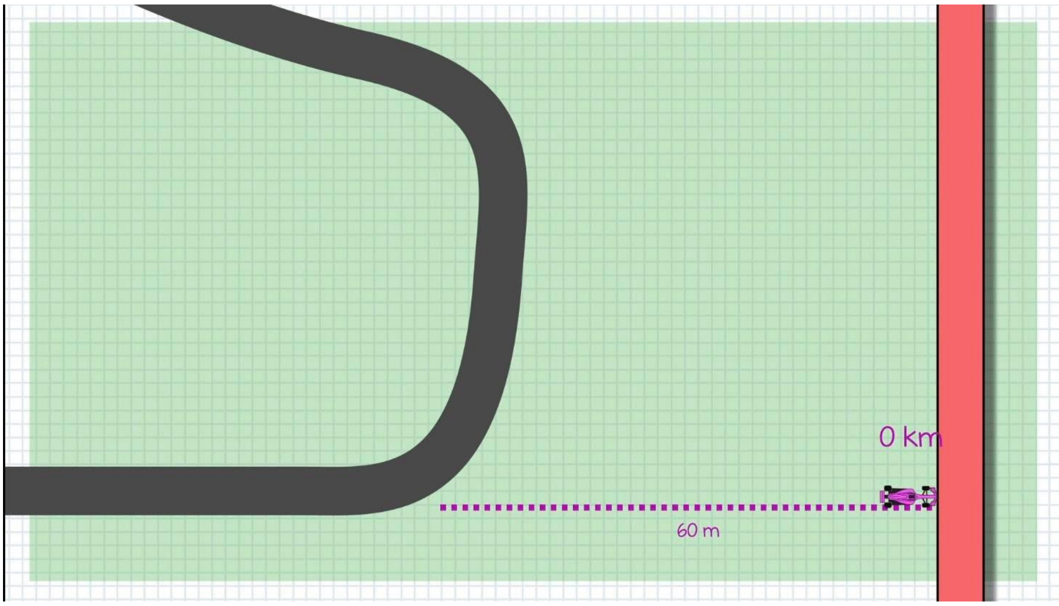


Figure 4.26: Runoff Deep Length 3

Materials like grass were used in run off areas, but later on, because of its low friction coefficient specially when its wet, grass started to be used in areas where cars are not likely to enter with high speeds and high skid resistance isn’t required, such as edges of straights and inside of corners. Gravel in run off was used and still used until today and it is installed when the car is expected to fly out from the track in a high speed. Table (4.2) shows the friction for some materials including grass and gravel (CHAINBEARF1, n.d.).

Table 4.2: Coefficients of Friction (Noon,1994)

Table 1: Coefficients of Friction of Various Roadway Surfaces (Noon, 1994)

Surface Type	Coefficient of Friction (μ)
Gravel and dirt road	0.35
Wet, grassy field	0.20
Dry asphaltic concrete	0.65
Wet asphaltic concrete	0.50
Dry concrete	0.75
Wet concrete	0.60
Snow	0.20-0.25
Ice	0.10-0.15
Loose moist dirt that allows tyre to sink about 5 cm	0.60-0.65

Gravel traps are to be installed with 0.25 m depth, and a grain size not less than 1 cm and not greater than 2 cm. Gravel traps are allowed to be more steeply inclined, in relation to the lateral projection of the track surface. Figures 4.26-4.28 helps to understand how gravel beds work in a simple concept (FIA, Appendix O, 2021) (CHAINBEARF1, n.d.).

Figure 4.27: Gravel Traps

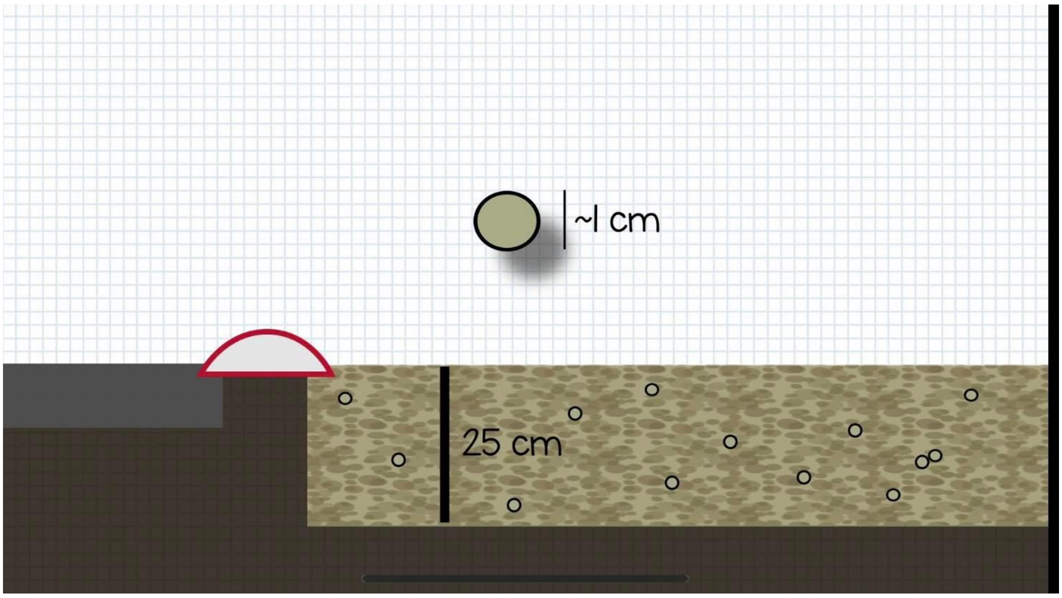


Figure 4.28: Gravel Size and Depth

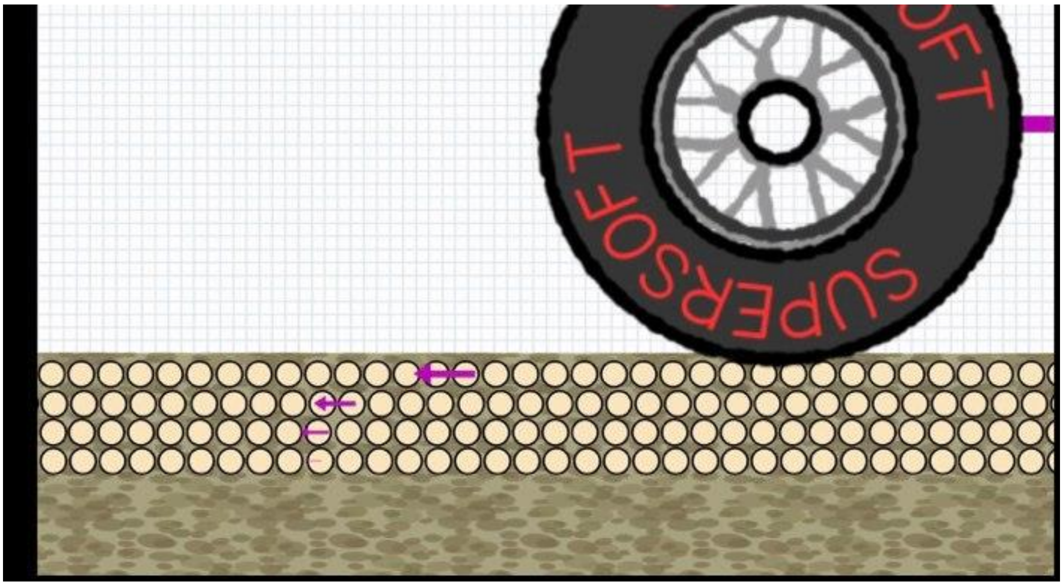


Figure 4.29: Load Action on Gravel

Still gravel and grass has less grip than the actual track surface, and skid resistance for car having interring the run-off area is still low, and can skip the whole area of run- off and hit the barrier in high speed.

To improve the resistance car momentum gravel traps, tend to be raked perpendicularly to the expected direction of car travel, which adds some undulation to the gravel, and can push back against the car and absorb its forward energy. Gravel traps are very effective when the car starts to spin or pitch slightly as the figure shows (CHAINBEARF1, n.d.).

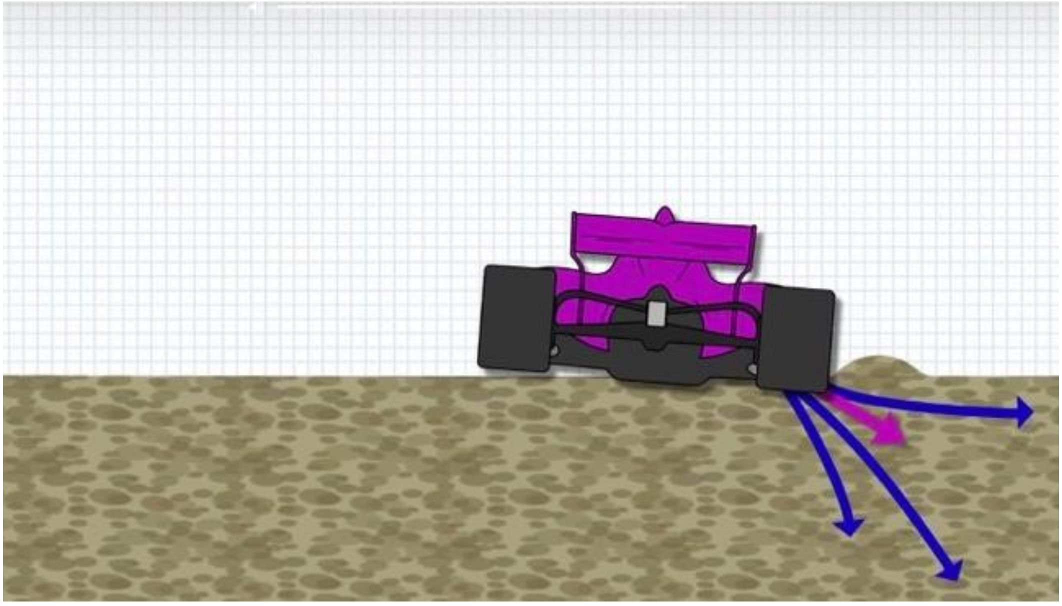


Figure 4.30: Sand Wave Caused by Cars 1

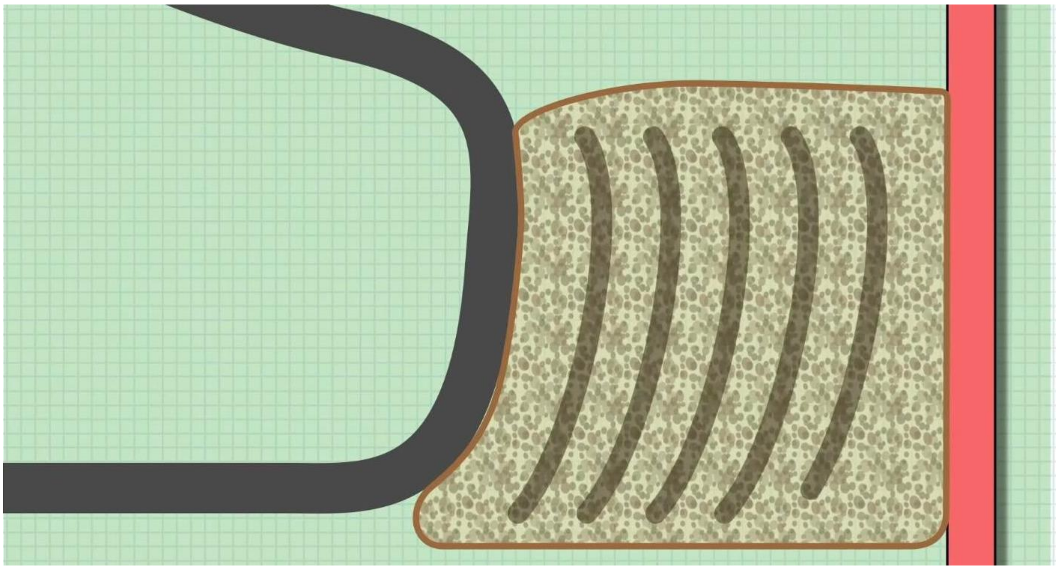


Figure 4.31: Sand Wave Caused by Cars 2

Tormac (Asphalt) Run – off areas: the safest form of run-off areas; they are grippy, stable, and predictable as they are essentially made of exactly the same material of the track. However, drivers can treat those run-off areas like an extra part of the track, which can give an advantage of leaving the track to these runs off areas, in which drivers can take the corner wider and go faster. These run-off areas are safety feature, and to prevent drivers from using it, Sausage Kerbs are used (CHAINBEARF1, n.d.).

Figure 4.32: Tormac Runoff 1

Figure 4.33: Tormac Runoff 2

4.3.5 The starting line.

Starting straight: a minimum width of 15 m should be carried along the starting grid until the exit of the first corner. For the standing start, there has to be at least 6 m grid per car, Formula 1 as special case 8 m (FIA, Appendix O, 2021).

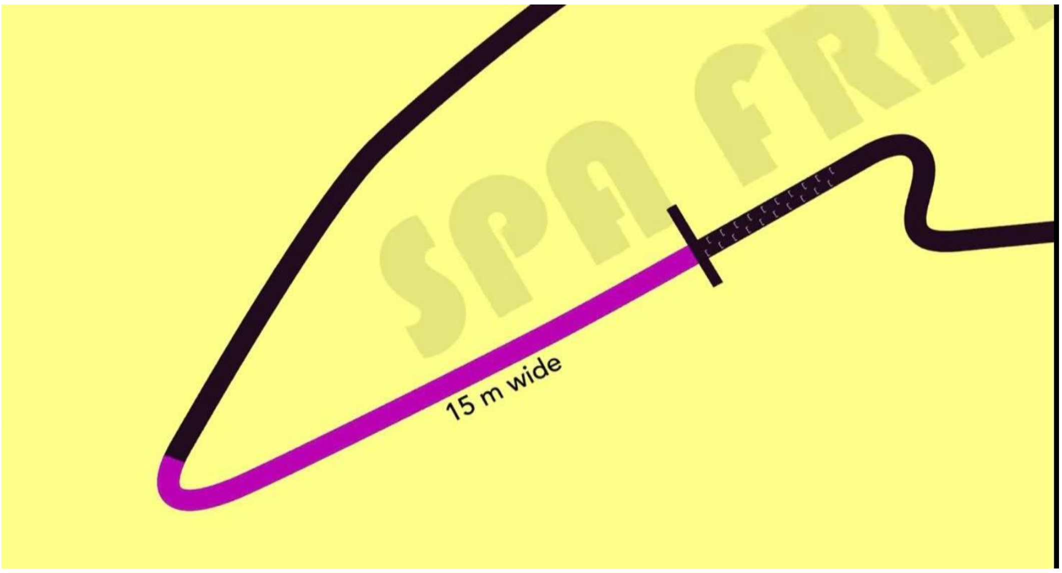


Figure 4.34: Starting Line Width

Figure 4.35: Starting Line Forming

The starting straight needs to have at least 250 m before reaching the first corner, with a change in direction with more 45 degrees and curve radius less than 300 m (FIA, Appendix O, 2021).

Figure 4.36: Starting Line Minimum Length

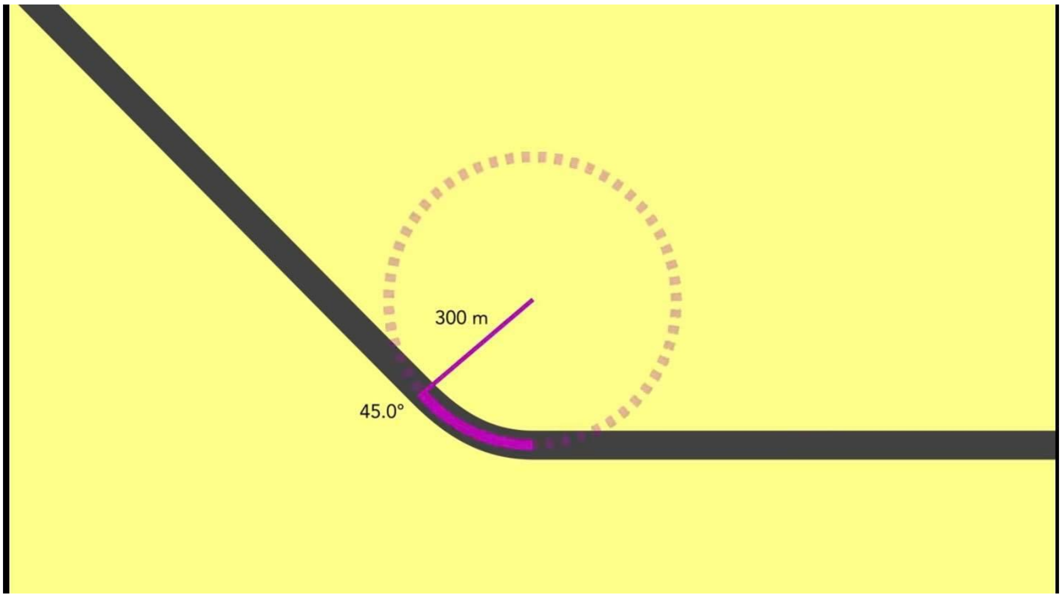


Figure 4.37: Starting Line Minimum Change of Angle and Maximum Radius

4.3.6 Circuit buildings and installations:

Here are various requirements for racing control, Timing Room, Marshal Posts, Pits, Paddock area, Medical Centers, garage area, Parc Fermé, light panels, pit entry and exit roads, and attenuation devices. Those requirements vary according the planned race; each project should be established by collaboration between the circuit management, the ASN (National Sporting Authorities) and the FIA.

4.4 Pit Lane

Pit lane: pit lane should be at least 12 m wide; it should be foreseen adjacent to starting straight, with garages and racing control faculties, and separated by pit lane and signaling platform Figure 4.38 (WTF1, n.d.) (FIA, Appendix O, 2021).

Figure 4.38: Pit Lane

The pit lane is divided into 2 lanes, the lane close to the pit wall is called Fast Lane, and the other that is close to the garages is called Inner Lane Figures,4.39 and 4.40. In the inner lane, there are Pit Boxes, such as shown in Figure 4.41. It's a marked area on the ground where the pit stops can be carried out (WTF1, n.d.).

Figure 4.39: Pit Lane Inner Lane

Figure 4.40: Pit Lane Fast Lane

Figure 4.41: Pit Lane the box

Adequate pit entry and pit exit lanes should leave and join the track at points avoiding interference with the racing line, with a proper merge to the racing road (FIA, Appendix O, 2021).

Emergency services and trucks must be able to pass in and out the track. This step should be carefully examined in planning stages, because it can influence the track layout in a high rate. For such approach, bridges and/or tunnels are to be installed and specified in planning stage (FIA, Appendix O, 2021).

If pit lane is used in practice or in racing, its speed limit shouldn't exceed 60km/h (FIA, Appendix O, 2021).

Figure 4.42: Ambulance in the Track

4.5 Race Management

Racing control room is the center of race supervision and direction and must provide the clerk of the course Figure 3.43. Race control should normally be located in the pit building Figure 4.44, at the pit entry end and no more than one floor above ground level. There should be an independent exit to the track or pit lane (FIA, Appendix O, 2021).

Figure 4.43: Control Room Interior

Figure 4.44: Control Room Exterior

Timing room: The timing room should be on the first or second level (not the ground floor) of the race control building and provide a clear and unobstructed view of the pit lane, track, the Control Line and the start/finish signals. (FIA, Appendix O, 2021)

Marshal posts: Surveillance of the track and its immediate surroundings is provided by marshal post staff Figure 4.45. For each circuit, the number and location of marshal posts vary according to the circuit characteristics Figure 4.46. Each marshal post shouldn't be distanced more than 500 m from other, taking in consideration that no section on road can escape observation, also marshals should be able to communicate with the preceding and following marshals (FIA, Appendix O, 2021).

Figure 4.45: FIA Marshal

Figure 4.46: Marshal Positions

Pit lane marshal: it's often that organizers provide marshal posts at the at pit entry and exist, with one more each 10 garages. This in order to warn drivers of any incidents that have occurred in the pit lane (FIA, Appendix O, 2021).

Signaling: In the supervision of the road, the Clerk of the Course (or his deputy) and the marshal posts rely largely on the use of signals to contribute to the drivers' safety and enforce the regulations. Signals are given in daylight by different colored flags, which may be supplemented or replaced by lights (FIA, Appendix H, 2021) (FIA, Appendix M, 2021).

Figure 4.47: Referee Last lap flag

Service roads: The emergency service requires an adequate number of vehicles holding areas and service roads behind the first line of protection and access points to the track, to enable the emergency vehicles to reach, unimpeded ,any point of the track and the medical center and the exits from the circuit quickly (FIA, Appendix O, 2021).

Figure 4.48: Services Road

4.5 Measurement of Circuit Length

The length of a circuit for the calculation of race distances, race records, and classifications are considered to be that of the centerline of the track.

The centerline of the track is the median line between the left and right edges of the asphalt of the track as delimited by the required white lines (FIA, Appendix O, 2021).

There are 2 approaches to measure the length of the racing circuit described as following:

1. **In filed measuring (preferred)**: on site measurements are taken in average from left and right edges.

   If this method fails, the FIA describes in detail a **geometric approach** to measure the length of the track by combining the longitudinal profile with the horizontal track with accuracy up to 1 m.

The geometrical form of the layout shall be defined in terms of plan and longitudinal profile along the track centerline, and this layout shall be used in the calculation of the official circuit length.

The plan definition shall include the horizontal centerline length of all straights and curves, the radius of all circular curves and the mathematical description of all transition curves.

The longitudinal profile shall be defined in terms of either vertical circular curves or a series of centerline levels at intervals of not less than 10 m, accurate to 0.01 m.

2. **Trackside advertising and structures:**

No advertising or decoration objects are allowed on the track surface, any surface installed decoration or advertising on paved run-off area mustn't reduce the skid resistance value. Any advertising object mustn't interrupt the visibility of drivers or officials, or produce a misleading optical effect, with its location or characteristics (FIA, Appendix O, 2021).

Figure 4.49: Allowed Advertising on Runoff

No form of advertising is allowed between the first line of protection barrier and the track. The only expectation is advertising panels for competition, which must be approved by the clerk of the course.

Any advertising or decoration object should be stable, secure, and able to resist winds (FIA, Appendix O, 2021).

Figure 4.50: Advertising Structures

Any advertising on the walls or guardrails of the first line of protection should be either painted on or in the form of adhesive posters, which in the case of guardrails, should follow exactly the contours of the rail (FIA, Appendix O, 2021).

Figure 4.51: Advertising on Barriers 1

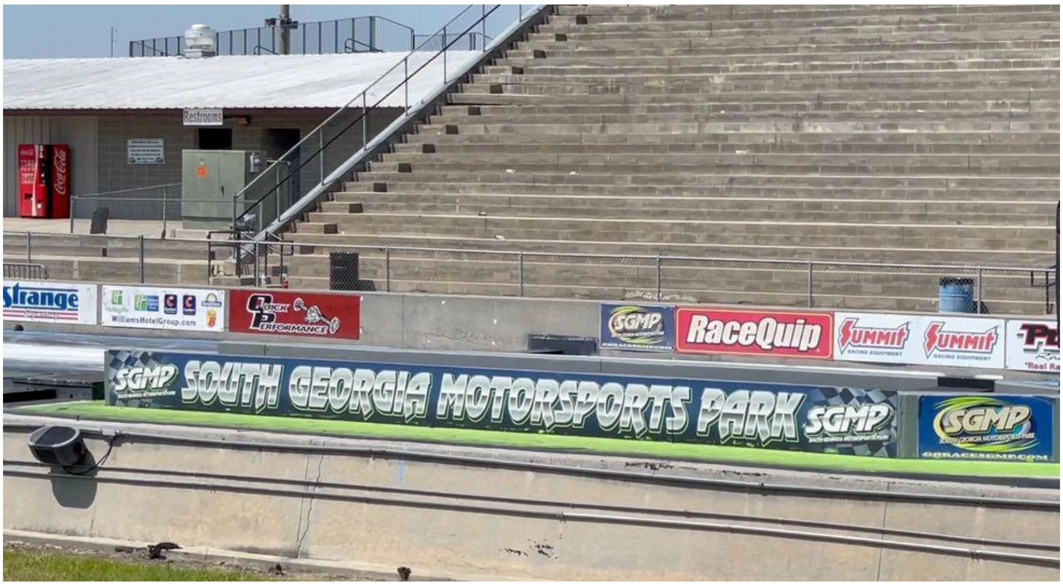


Figure 4.52: Advertising on Barriers 2

All structures must be approved specifically by the clerk of the course or by the race director. All overhead structures extending the first line of protection must provide 4-meter clearance at least, and they must be approved by an engineer to ensure strength and stability standards. Any structure behind the first line of protection must be 1 m behind, and it shouldn't interrupt the circulation or emergency cars (FIA, Appendix O, 2021).

4.7 Maximum Number of Cars during One Event on Track

Based on Appendix O provided by the FIA (2021), the maximum the number of cars allowed to start in an international race based on this equation:

N= 0.36 x L x W x T x G (N to be rounded up to the next whole number).

L: Number based on Circuit length (km).

W: Number based on Reference width (m).

T: Number based on race Duration (hours).

G: Number based on Type of cars.

The following table specifies the conditions for the above coefficients Table 4.3.

Table 4.3: The Variables of the Maximum Number Equation

L		W		T		G	
Length km	**L**	**Width m**	**W**	**Duration h**	**T**	**Category**	**G**
2.0-2.6	10	8	9	<1	1	N, A, B, GT	1
2.6-3.2	11	9	9	1-2	1.15	Historic Touring /GT	1
3.2-3.8	12	10	10	2-4	1.25	Single -seaters <=21	0.8
3.8-4.4	13	11	10	4-12	1.4	Sports Car >21	0.7
4.4-4.8	14	12	10	>12	1.5	Single seaters >21	0.6
4.8-5.2	16	13	11.5				
5.2-5.6	17	14	12				
5.6-6.0	18	15	12.5				
6.0-8.0	17						

5 DATA COLLECTION

5.1 Definitions

Course: represents a road or track, and the inherent installations used for automobile competitions.

Circuit: is a closed course including inherent installations, beginning and ending at the same point, built or adapted specifically for automobile racing. Course and circuit may be permanent, semi-permanent, or temporary structures.

The track: is a road specially built or adapted for circuit competitions and defined by the outer edges of the racing surface.

Track edges: as an area between the outer edges of the track and the first line of protection while service areas are defined as areas between the first and second line of protection.

Trip generation rate: Trip generation rate shall mean the number of vehicle trips over a weekday twenty-four-hour period generated by a particular type of land use and shall be expressed in terms of the number of acres or square feet of land for each land use category.

racing line: is the path that the vehicle is thought to move fastest round the track. It is known that the racing line will vary depending on the driver and driving style and vehicle setup so its definition is partly subjective

Design speed: is the speed that the racing track was designed according to it, racing speed is important to determine, its associated with friction coefficient on the track asphalt to avoid over sliding, designing the curve sections, also to design the straight sections, to provide a safe racing experience, giving the ability to races to show what their cars can pull out.

Superelevation, inclination: is elevating a section of the roadway along with the horizontal curve, it provides a safe and comfortable maneuver to the driver interring the curve with reasonable speed (less than the limit speed), superelevation provides stability for the car on the curve, the relation between the superelevation value and speed is orthodox،thus, more speed requires more banking for the roadway.

vehicle set up: relates to adjustable parts that would be set on race days in response to weather, driver/rider preference and race track characteristics. Adjustable vehicle parts include shock absorbers and anti-roll bar (suspension), gear ratios and differential, tire pressures and type, wing angles, wheel toe-in and camber angle, brake bias, steering lock and ride height.

Declaration coefficient and k constant: It is the rate at which an object slows down. Deceleration is the final velocity minus the initial velocity, with a negative sign in the result because the velocity is dropping, such as gravel, asphalt and gravity coefficients. The constant k is a value that has been found from analysis of the accident data recorders and relates the deceleration coefficients to current vehicle specifications.

Tangential arc and line geometry: defines step changes in curvature at tangents. A race car on the track would actually transition smoothly from straight to corner (continuity of curvature). The curvature continuity achieved with tangent geometry is an approximation which is currently considered sufficient for the purposes of design.

5.2 Track Body Parts

1. Straightaway - exactly what it sounds like, a straightaway is "straight" in nature. This chunk of track is meant to let drivers really push the speed limits of their cars. Seen in every style of racing, the straightaway is often where the start/finish line is located. No matter how long, the straightaway is most often the stretch that is the quickest.
2. Banking - referring to the degree of the racing surface, banking is common in all types of racing. The higher the banking, the more the cars can stick to the surface due to downforce. However, it is not necessary for racing at high speeds. In fact, one of the fastest tracks in the world, the Indianapolis Motor Speedway.
3. Inside lane: the part of a circular track for sports races that is nearest the center and is the shortest distance round the track
4. Inside track: an inside lane for a race
5. Line: a long thin mark on the ground used in sports for marking an area in which a match is played, or for showing where a race starts or finishes

6. On the inside: if someone in a race is on the inside, they are on the part of a circular track that is nearest the center
7. Start: the place where a race begins
8. Starting line: the line or point where a race starts
9. Stretch: the straight last part of the track in a race

5.3 Strategies of Collecting Data

it was hard to find a reliable source of information can be trusted and taken for granted, since the current racing yards are owned by individuals not by special institutions, and those individuals don't have the knowledge of the design or the construction of the track, which does not answer the questions needed.

5.3.1 Interviews

5.3.1.1 Data from Abdul Hakim Al-Shiny

Abdul Hakim Al-Shiny explained about racing events in the West Bank, for example, the season starts at April and it ends at November. Many racing events may occur in a year, the length of each one those events are 2 days, total, the number of cars attend the race did not accede 80, the number of audiences usually came to watch in average is 800 and once it reached 2000, and a review of the cars that might race and categories of them.

5.2.1.2 Data from Arch (Iyad Sawalha)

An interview was made with a designer for a race track. The data provided was through interviews with the engineer and through calls also. The engineer provided information about the minimum length of speedway racing track (500m), the minimum area for the drifting yard (4000m²), gave interval of the upper limits and lower limits of the number of audiences (1200 - 5000) that might attend the racing event. Also, the engineer gave ideas about the shape of the whole arena with layouts that suit the land space chosen. The engineer also advised to have movable audience seats, based on experience from abroad; He referred to Cyprus arena as an example. Movable seats give the capability and flexibility to adjust the space inside the arena according to the event going on.

5.3.2 Site visits

Ramallah Drifting Yard: A look into racing inside the West Bank.

This gave a general idea about racing events and racetracks in the West Bank, seeing the nature of used vehicles, types of safety, places of referees, garage, parking, inter gate, and out gates.

The Sarsour Karting is accredited by the Federation for Racing, but it's not properly designed according to the FIA specifications. Therefore, it can't be a reference or criteria. It is considered as a sample of social racing and activities. In (Figure 5.1) it shows the karting track, as seen it does not follow the criteria that was discussed in section 4.2. Firstly, the 3 levels of barriers are missing and secondly the width of flat bend (Al-Sarsour, 2021).

Noticing that sensors used for recording time of each lab (Figure 5.2), which, in turn, encourages competition and demonstrates an accurate interest in detail. Leading to the importance of missing barriers to keep the driver safe in case of a crash occurs (Figure 5.3 and 5.4).

Figure 5.1: Sarsour Track 1

Figure 5.2: Sarsour Track 2

Figure 5.3: Sarsour Track 3

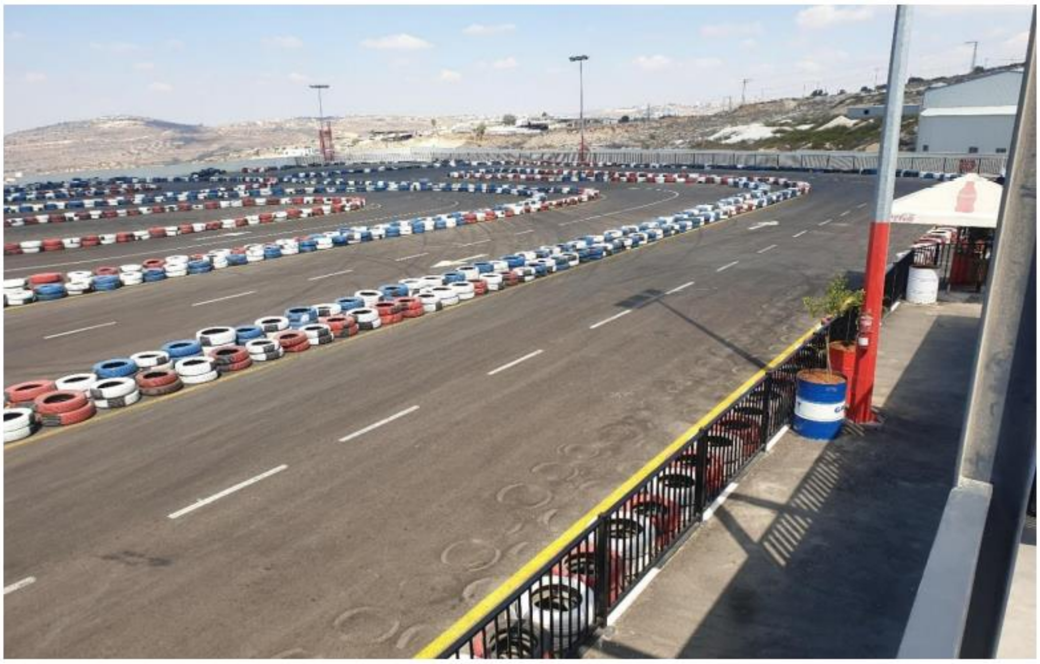


Figure 5.4: Sarsour Track 4

5.3.3 Online Sources

This process was done to find the requirements to design the circuit and the general information about the circuits, the information that was gathered from in this stage was he, so a complete chapter describing the information was added.

5.4 Data for Trip Generation Rate

Estimating trip generation rate helps in the initialization of the surrounding street to adopt the extra traffic volume, also, counter any future problems that includes congestion in the area. It might influence the choosing of circuit location, because it might generate a new traffic volume can't be absorbed with current site regulation.

Moreover, designing the parking facilities for race track is dependent on such rate, which determines the size of the facility, also it helps in estimating the number of seats needed in the arena.

5.4.1 Data from San Diego Trip Generation Rate Manual

The trip generations 0.6 for a racetrack according to this manual (Manpalicity, 2002).

RECREATION	
Beach, Ocean or Bay .... [52:39:9]	600/1000 ft. shoreline, 60/acre*
Beach, Lake (fresh water)	50/1000 ft. shoreline, 5/acre*
Bowling Center	30/1000 sq. ft., 300/acre, 30/lane **
Campground	4/campsite**
Golf Course	7/acre, 40/hole, 700/course* **
Driving Range only	70/acre, 14/tee box*
Marinas	4/berth, 20/acre* **
Multi-purpose (miniature golf, video arcade, batting cage, etc.)	90/acre
Racquetball/Health Club	30/1000 sq. ft., 300/acre, 40/court
Tennis Courts	16/acre, 30/court**
Sports Facilities	
Outdoor Stadium	50/acre, 0.2/seat*
Racetrack	40/acre, 0.6 seat*
	en'
RESIDENTIAL .... [86:11:3]	
Estate, Urban or Rural (average 1-2 DU/acre)	12/dwelling unit*R
Single Family Detached (average 3-6 DU/acre)	10/dwelling unit*R

Figure 5.5: The Trip Generation Rate

5.3.2 Data from Utah Trip Generation Rate

The trip data for the morning peak period, the afternoon peak period, and the peak hour of the generator are shown in Table (5.5.1) (chapter, 2014).

The data were collected starting at 9 a.m. on Thursday, so the morning peak data were not available for that day. Data about vehicle occupancy was not collected during this study. Bicycle trip data were also collected as part of this study and can be found in the attached Trip

Generation Data Forms. The bicycle trip counts proved negligible. Data on pedestrian trips were collected, however, no pedestrians were observed using the two recorded accesses on any day (chapter, 2014).

Table 5.5.1: Parking Collected Data

Thursday (3/13/2014)			Friday (3/14/2014)			Saturday (3/22/2014)		
Entering	Exiting	Total	Entering	Exiting	Total	Entering	Exiting	Total
1028	905	1933	867	723	1590	2154	1949	4103
53.2%	46.8%	100.0%	54.5%	45.5%	100.0%	52.5%	47.5%	100.0%

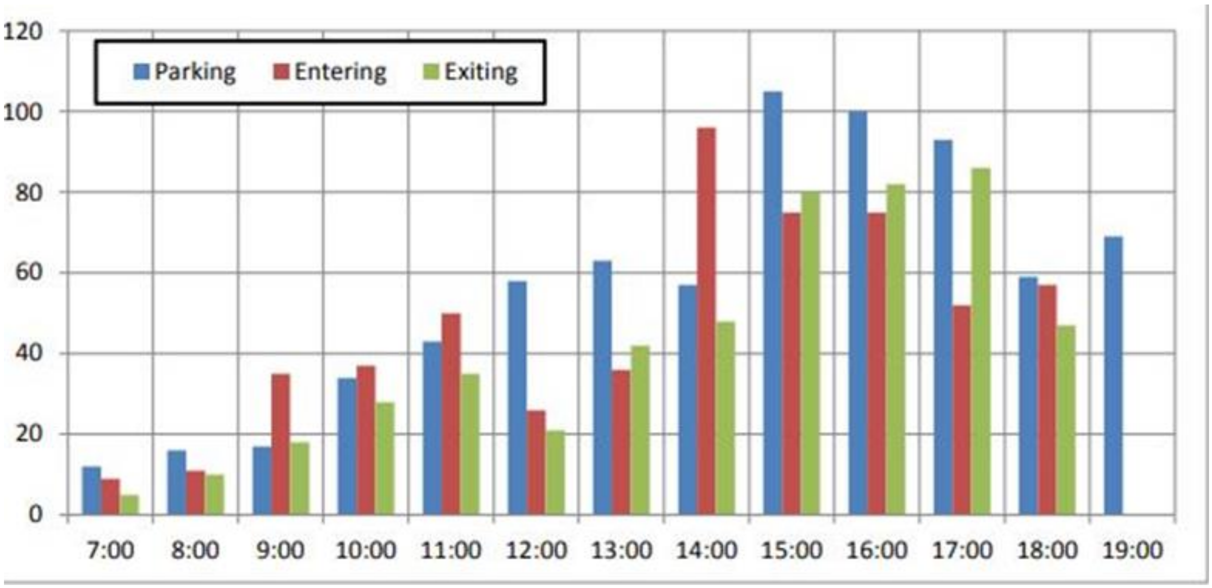


Figure 5.6: Comparison For The Parking Results

6 RESULTS & ANALYSIS

After data were collected, it goes into an analysis method to get information that will be used in the design. The first step of analyzing is to compare with the regulations. If it's not in regulations the FIA leaves that to the designer, then have to choose according to some conditions.

6.1 Car Racing in Palestine

As the first step in conducting this project, it was necessary to understand the trend of racing in Palestine. During the research process, it was discovered that car racing is becoming more popular along with car modifications, but that the available tracks do not meet the need, and that the tracks cannot accommodate the potential some cars possess.

In Palestine, usually, six racing events occur throughout the season each year, three for drifting and three are automobile racing. These events have a range from 30-80 cars participating, the duration of these events usually is from 9 am - 4 pm, and these events have spectators ranging from 800 to 2000 (Al-Shinny, 2021).

Based on interviews and research. It was concluded that the designed track should be able to accommodate 5000 spectators and provide parking needed for them, also with faculties that serve them, to match the needs of the sport. In addition to teams and their cars. The advertisement should be also taken into consideration its needs (Sawalha, 2021).

To understand what is to be included and designed, it is necessary to ask what the funding party actually wants and needs. According to an interview with a member of PMSMF (Professional Motor Sports Motorcycle Federation) the participating cars vary a lot, and dividing them into categories is tough because many modify the cars. In this case, the design car is a Mercedes-Benz C63 AMG.

6.2 Car Racing in the World

Around the world, there are now numerous different car categories, each with different rules and regulations. This leads to a huge variation in circuits and races to be held in them (Wikipedia, 2022).

The sizes of the cars range from small cars, such as the miniature convertible cars that were called Jokarts in the past, to racing cars. All racing cars can be divided into two main groups:

A. Production cars

B. Cars specially built for racing.

Production vehicles include cars that were originally made for passengers after being converted into racing cars. Most cars built specifically for racing are not designed to carry passengers (Wikipedia, 2022).

Most motor racing is held on closed circuits or tracks, some of which are oval, characterized by short straight tracks and curves that may be sloping. The floors of most of the oval arenas are asphalt, but the rest of them are dirt floors. There are other types of irregularly shaped circuits that include various straights, hills, and curves with steep inclines. The many turns are described by their names, such as hairpin, dog's leg, and the English letter S (Wikipedia, 2022).

There is a lor of kinds of car races, such as.

1. Open -wheel racing (F1, F2---F6, F SAE):

Figure 6.1: Formula1 Cars

2. Touring car races

Figure 6.2: Touring Cars

3. Sports car racing (GTs)

Figure 6.3: Sport GT Cars

4. Rallying (Group N and Group A)

Figure 6.4: Rally Cars

5. Karting

Figure 6.5: Karting Cars

6. Rallycross

Figure 6.6: Rallycross Cars

6.3 FIA Circuit License Grades

FIA circuit licensees are issued in grades from 1 to 6 according to the types and groups of cars for which it is deemed that the circuit is suitable and are issued with the sole purpose of permitting the registration of races on the FIA International Calendar, for the categories of vehicles specified. The types and groups indicated below correspond to the classification established in Article 1 of Appendix J and to the FIA regulations for historic, offroad and alternative energy vehicles (FIA, Appendix O, 2021).

Each license grade is also valid for all categories of cars in the grades below it, 1 being the highest grade (FIA, Appendix O, 2021).

GRADE	CATEGORIES OF CARS
1.	Automobiles of Groups D (FIA International Formula) and E (Free Formula) with a weight/power ratio of less than 1 kg/hp. Historic cars according to the table below. Historic cars – Formula One Post-1985.
1E.	Electrically powered Automobiles with a weight/power ratio of less than 1 kg/hp or as defined in the current FIA Formula E Sporting Regulations.

Figure 6.7: Grade Categories 1 (Source: FIA, Appendix O, 2021)

ANNEXE O
APPENDIX O

1T.	Testing of Previous F1 Cars (TPC) as defined in the current FIA Formula 1 Sporting Regulations.
2.	Automobiles of Groups D (FIA International Formula) and E (Free formula) with a weight/power ratio of between 1 and 2 kg/hp. Historic cars according to the table below.
2E.	Electrically powered Automobiles with a weight/power ratio of between 1 and 2 kg/hp or as defined in the current FIA Formula E Sporting Regulations.
2T	Testing of automobiles with a weight/power ratio of between 1 and 2 kg/hp.
3.	Category II Automobiles with a weight/power ratio of between 2 and 3 kg/hp. Historic cars according to the table below.
3E.	Electrically powered Automobiles with a weight/power ratio of between 2 and 3 kg/hp or as defined in the current FIA Formula E Sporting Regulations.
3T.	Testing of automobiles with a weight/power ratio of between 2 and 3 kg/hp.
4.	Category I Automobiles. Category II Automobiles with a weight/power ratio higher than 3 kg/hp. Historic cars according to the table below and in compliance with the provisions of Appendix K if not included in Grades 1, 2 and 3.
4E.	Electrically powered Automobiles with a weight/power ratio of above 3 kg/hp or as defined in the current FIA Formula E Sporting Regulations.
4T.	Testing of automobiles with a weight/power ratio higher than 3 kg/hp.

Weight = weight of vehicle in kg in running condition including driver at zero fuel as described in the relevant technical regulations.

** Power = maximum power output of vehicle in hp as measured at the crankshaft.

Figure 6.8: Grade Categories 2 (Source: FIA, Appendix O, 2021)

ANNEXE O
APPENDIX O

Automobiles historiques / Historic Automobiles		
Degré Circuit / Circuit grade	**Période concernée / Period concerned**	**Catégorie-Classe / Category-Class**
Grade 1	J	Formule 1 post-1985 / Formula One post-1985.
Grade 2	G/H/I/J	Automobiles : F1/4 – F2/4 – F2/5 – F5/2A – F5/2B – F3000/1A Automobiles : TSRC17 – TSRC18 – TSRC51 TSRC28 – TSRC29 – TSRC30 – TSRC52 TSRC40 – TSRC41 – TSRC42 – TSRC53 TSRC46 – TSRC47 – TSRC48 – TSRC54 Automobiles de Tourisme et Grand Tourisme Groupe 5 / Touring Automobiles and Grand Touring Group 5 : HST4 – HST5 Automobiles de catégorie spécifiques américaines / Period G, H and I Automobiles in specific American categories : AN/1G – CAN/1H – CAN/3 Autres Automobiles biplaces de course / Other two-seater racing Automobiles : GC/1A – GC/1B – GC/2A – GC/2B
Grade 3	F/G/H/I/J	Monoplaces / Single-seaters: F1/3 – F3/4 – F5/1
Grade 4		Automobiles historiques conformes au règlement de l'Annexe K non incluses dans les Degrés 1, 2 et 3 ci-dessus / Historic Automobiles in compliance with the provisions of Appendix K not included in Grades 1, 2 and 3 above.

Figure 6.9: Grade Categories 3 (Source: FIA, Appendix O, 2021)

According to the FIA, the FIA licenses a number racing circuits according to car classification in releases J and K Appendices. for this project, a touring car (**Mercedes Benz C63 AMG)** was chosen Table 5.1, this car races in Grade 2 according to the FIA specifications, thus the Grade of this project track is 2.

Table 6.1: The Designed Vehicle Specifications

Engine type - Number of cylinders:	V 8
Engine size - Engine capacity:	6208 cm3 or 378.8 cu-in
Bore x Stroke:	102.2 x 94.6 mm
Number of valves:	36 Valves
Compression Ratio:	11.3
Maximum power - Output - Horsepower:	457 PS or 451 bhp or 336 kW @ 6800 rpm
Maximum torque:	600 Nm or 442 lb. Ft @ 5000 rpm
Wheelbase:	**276.5 cm or 108.86 inches**
Length:	**472.5 cm or 186.02 inches**
Width:	**179.5 cm or 70.67 inches**
Height:	**143.8 cm or 56.61 inches**
Aerodynamic drag coefficient Ch:	**0.32**
Front Brakes - Disc dimensions:	**Vented Discs (360 mm)**
Rear Brakes - Dices dimensions:	**Vented Discs (330 mm)**
Front Tyres - Rims dimensions:	**235/40 R18**
Rear Tyres - Rims dimensions:	**255/35 R18**
Kerbs Weight:	**1730 kg OR 3814 lbs.**
Weight-Power Output Ratio:	**3.8 kg/hp**
Trunk / Boot capacity:	**L**
Front Suspension:	**Independent. McPherson struts. Coil springs. Anti-roll bar.**
Rear Suspension:	**Independent. Coil springs. Anti-roll bar.**

6.4 Circuit Design

6.4.1 Track Layout

Drawing a layout is the first step in the planning stage, the layout is usually restricted in shape by its surroundings, the length of the track, the nature of the race, property area, in-service roads, tunnels, and bridges. There are famous tracks more than others, due to their layout, location, and historical value. The track layout isn't just curves and straights it's far from that the layout represents competition, challenges, and excitement (MOTOR, 2018).

Drawing the layout went through stages, in which a certain one was agreed on and servers the purpose of the project. A general layout for the circuit contains the locations of: start-end, pit lane, grandstand's locations, structures (control room, garages, timing room, emergency room and Run-Off areas; Figure 6.10 and 6.11.

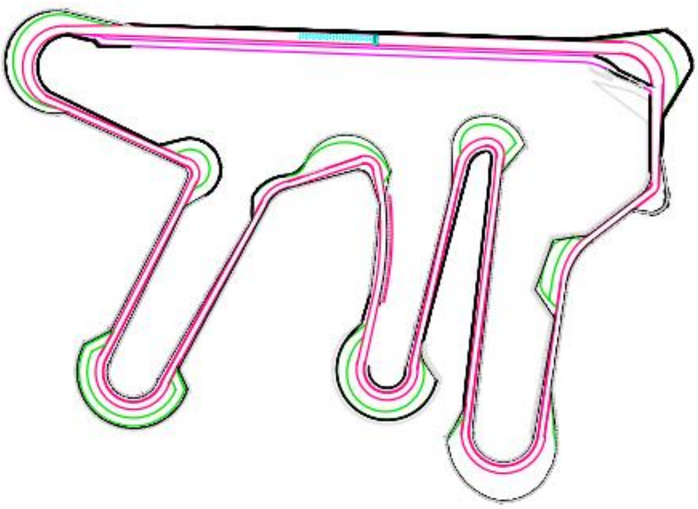


Figure 6.10: Runoff Areas

See the Appendix

6.4.2 Corners and Racing line

Corners:

Corners vary in type, each corner is specified mainly by 3 points, these 3 points identify the racing line inside the corner, turn in, Apex, turn out consecutively, the racing line passes through the Apex at the middle of the curve (dictionary, 2022).

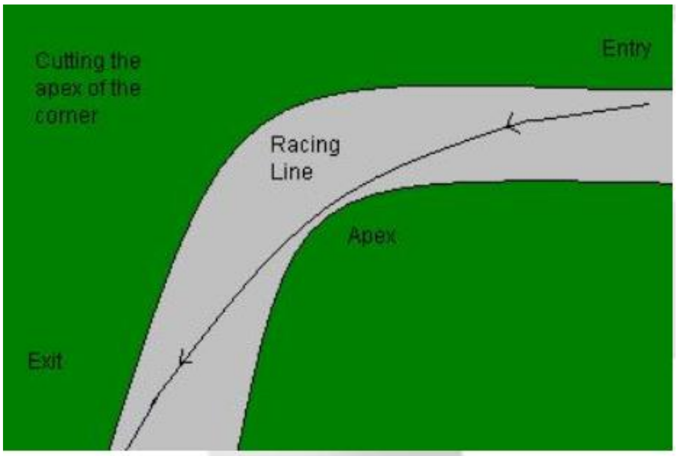


Figure 6.11: Racing Line

Single radius corners:

Is one that has a quick gentle turn-in, a long consistent apex, and a gentle exit. Providing the track is fairly level, setup for the corner can be tackled in a fairly routine manor (dictionary, 2022).

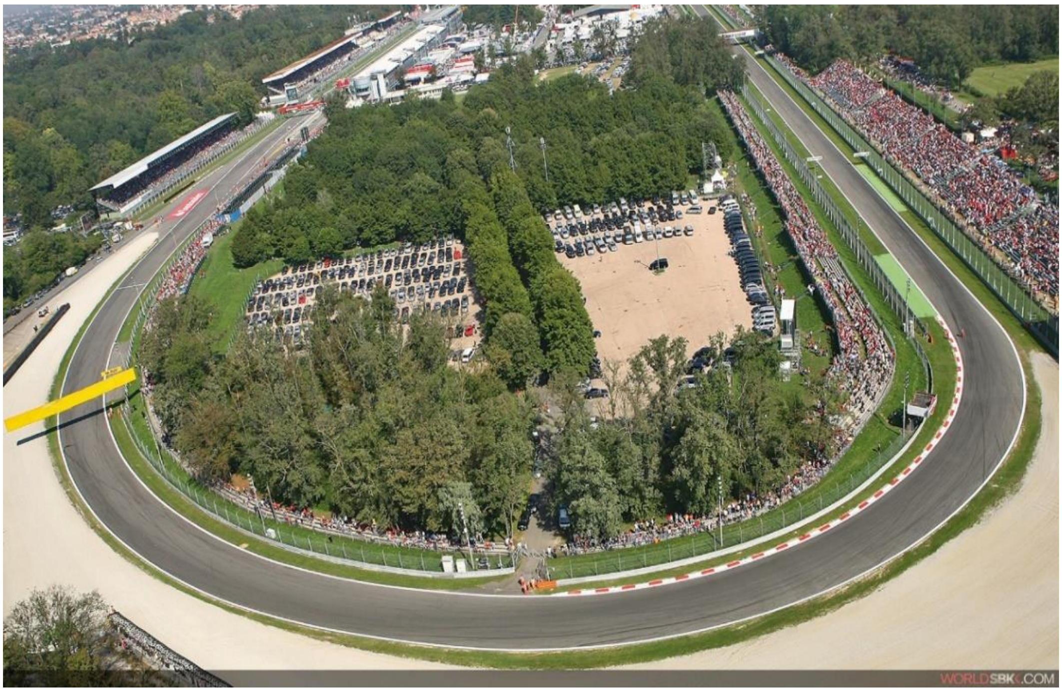


Figure 6.12: Single Radius

Increasing radius corner:

Is one that features a longer corner exit than corner entry, and is usually accompanied by a small corner apex. In this type of corner, the idea is to brake late and turn in sharp, advancing the corner apex early, then quickly and progressively accelerate for maximum exit speed (Wikipedia, 2022).

Figure 6.13: Increasing Radius

Decreasing radius corners:

A decreasing radius corner is indeed one of the most difficult corners to setup for. The braking zone follows an arc leading to the late apex (dictionary, 2022).

Figure 6.14: Decreasing Radius

Fast speed esse's corner:

A fast esse is typically a combination of two or more corners. At these speeds, aerodynamic balance is a key factor. But probably equally important is the correct line which allows the fastest cumulative sector time (dictionary, 2022).

Figure 6.15: Fast Speed

Medium speed esse's:

Like a fast esse, the medium-speed esse is typically a combination of two or more corners. Here, however the springs and dampers are more important than aerodynamics, mainly due to the fact that the car is either increasing or decreasing speed as it traverses these corners (dictionary, 2022).

Figure 6.16: Medium Speed

Chicanes:

Chicanes are essentially slow esses, so all of the medium esse characteristics apply here. Also, because the phases happen in rapid succession (do to the overall smaller size of the chicane), car imbalances tend to be magnified at the point of weight shift during the change of direction. Also, the overall slower speeds mean aerodynamics is less of a factor in car balance and mechanical grip has a great deal of influence. Due to the tight nature of most chicanes, riding over kerbs is an acceptable risk. Many times, a chicane will be the slowest corner on a particular circuit (dictionary, 2022).

Figure 6.17: Chicanes Corner

Hairpin corners:

Hairpin corners stress the cars braking capabilities to their maximum. Typically, the car is being coaxed into slowing from top speed down to anywhere from 60kmh to 100kmh. Good front-end grip is essential to allow a driver to be competitive here, particularly when passing. The turn-in comes early and the short apex is at the middle of the inside kerbs (dictionary, 2022).

Figure 6.18: Hairpin Corner

Double apex corner:

From time to time, two successive corners will line up in such a way that it enables a driver to attack them both as a single corner. This means the first corners' exit (phase 3) and the second corners' entry (phase 1) become essentially both corners phase 2, or the overall corner apex. In this instance, the 2nd phase is rather large and may contain some throttle adjustments (dictionary, 2022).

Figure 6.19: Double apex Corner

All corners in this project are single radius corners.

Racing lines:

The mathematical racing line is the fastest profred path that the car takes inside a corner, the racing line passes through 3 main points, Turn in Apex & Turn out. The geometric Apex is the inside most point of a corner that cars brush past on their line through corner, the geometric Apex in simple corner produces a line though the turn (dictionary, 2022).

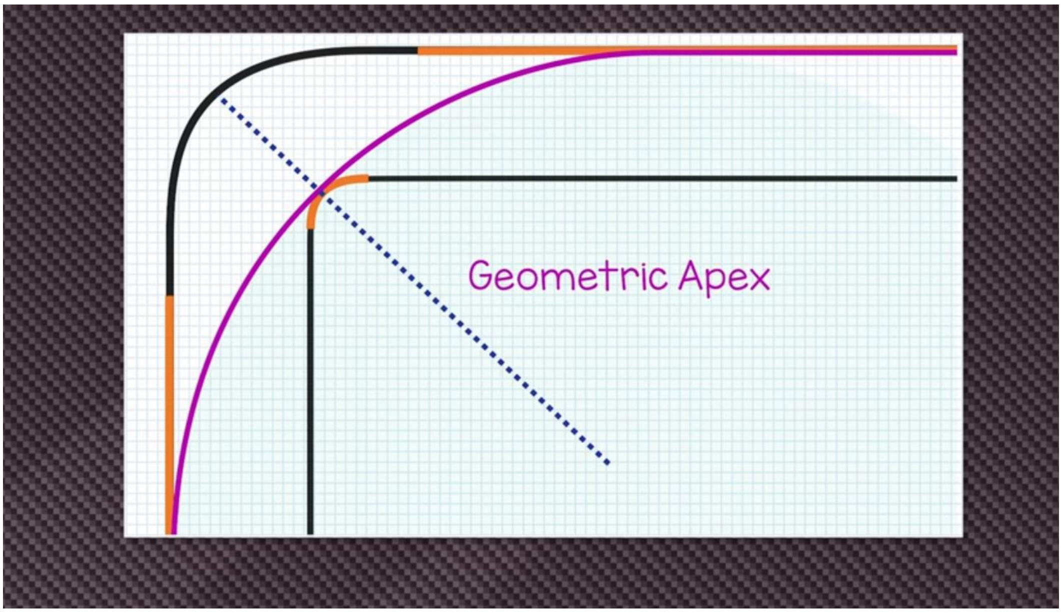


Figure 6.20: Geometric Apex

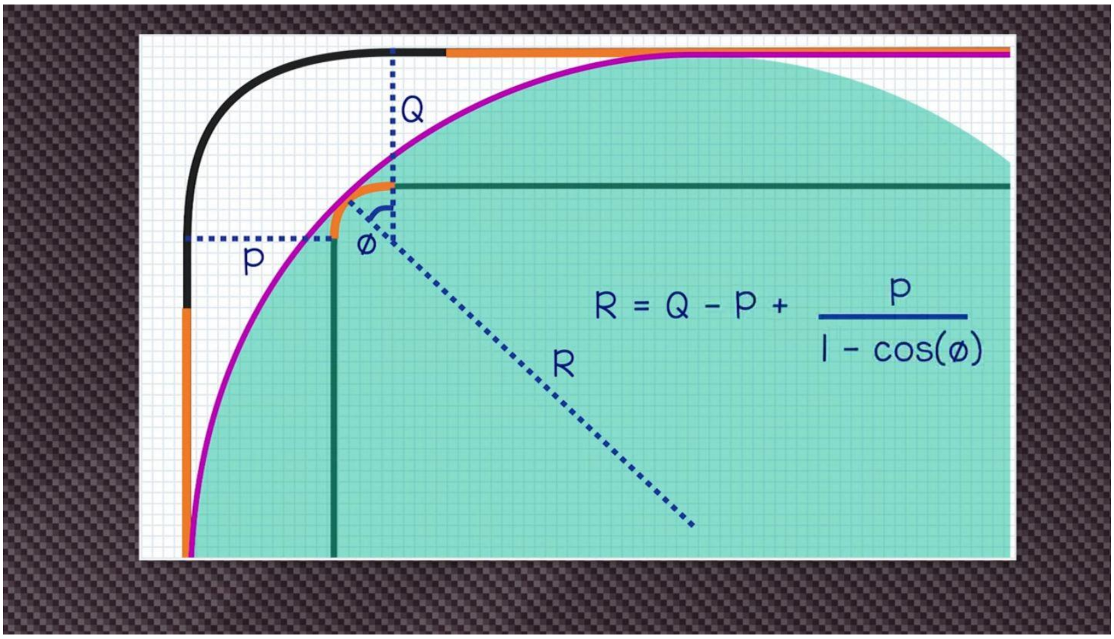
Any racing line passing a corner has much larger radius than any path which follows the curve of the corner itself, it's not always the best option to take racing line inside corners, in races drivers come across set of corners and straights in between, sometimes distorting the racing line gives the car the potential of passing the last corner of the set-in maximum speed, which actually the purpose. distorting the racing lines gives early apex and late apex, the early apex is preferred in hard and narrow corners., in which it gives the driver a higher acceleration rate at the turn out of the corner (dictionary, 2022).

Conducting a racing line for the track is fundamental, the racing line allows the designer to compare speed results from simulation to what was calculated. Conducting racing line for simple corner is easy, but, for other types of corners the process is complected, multistage methodology is practiced with 3D program analysis and driving simulator to whole design process (Barišić, 2019).

For this project, simple corners were chosen to be for all curves, because calculating the racing line for other corners requires programs and time out of the scope of this project.

The mathematical racing line for corners was calculated in simple formula as the following (CHAINBEARF1, n.d.).

$$R = Q - P + \frac{P}{1 - cos(\emptyset)}$$



The racing line for the track was generated, the racing line allows the designer to calculate possible speeds at each corner, thus, designing a safe track.

See the Appendix

6.5 Calculations

6.5.1 Track

Starting grid and starting straight

The grid space is 6 m, the length of the starting straight is (490) with radius of (75), and first corner change of direction (89 degrees).

Track length

Based on the FIA specifications, for touring cars and duration more 6 hours, the minimum track length should be more than 4 km, and the maximum shouldn't pass 7 km; in this project the track length is 4.3 km and matches the requirements.

Track width

Track width is 20 m from starting grid to the end of the first corner, 14 m across corners curves, and 12 m in the rest of the track. The change of width across all the track doesn't accede the of 1/20, these numbers match the FIA specifications.

Grades

Grid line gradient is assumed to be 0. All corners are inclined transversely with grade of 5% from edge to edge, and the longitudinal profile gradient from start /finish is 2%

Track edges, verges and run-off areas

Verge width is 1 m, there are 2 types of Runs off areas used in this project, gravel and asphalt, both of Run-off areas are more than 30 m and average with 43 m with upward slope of 5 degrees, gravel grain size is assumed to be 1 cm, and the depth of the layer is assumed to be 25 cm for gravel, and 15 cm for asphalt. In all corners asphaltic run off area comes first then gravel. areas that have low speed and cars are not expected to inter has grass in it.

Kerbs is assumed to be 1 m width on any section they exist on, Sausage Kerbs exist on the corner outside apex.

Barriers

Guardrails or concrete walls are used wherever the car is expected to slide with a large parallel component, while techpro barriers are used after run off areas in order to absorb the cars energy and make it stop. Between the track and the pit lane there is concrete barrier, between spectator's grandstand and the track there is spectator's fence.

Pitlane

The pitlane is divided into 2 lanes, each has 6 m width, pitlane has length of approximate 1130 m, and 2 marshal boxes, one at start and one at the end.

Marshal posts

The locations of marshal posts were chosen according to the FIA standards and no sections escape inspection, in a way there is no obstructs between them and posts can communicate efficiently, and distance is less than 500 m between any 2 successive posts.

See the Appendix

6.5.2 STRUCTURES

Pitlane structures

In this area, garages, control room, pit tower and timing room exist, garages are in the first floor next to the inner lane of pitlane road. Timing room and control room are in the second floor. These structures weren't designed in this project, they are over the scope and time of this part project, if there is continuation for this research, they have to be designed according to the FIA specifications, enough space is left for such purpose.

Spectators' area structures

This area includes the grandstand of spectators and carnival building, carnival building wasn't designed, grandstand was designed to accommodate 5000 spectators as the following.

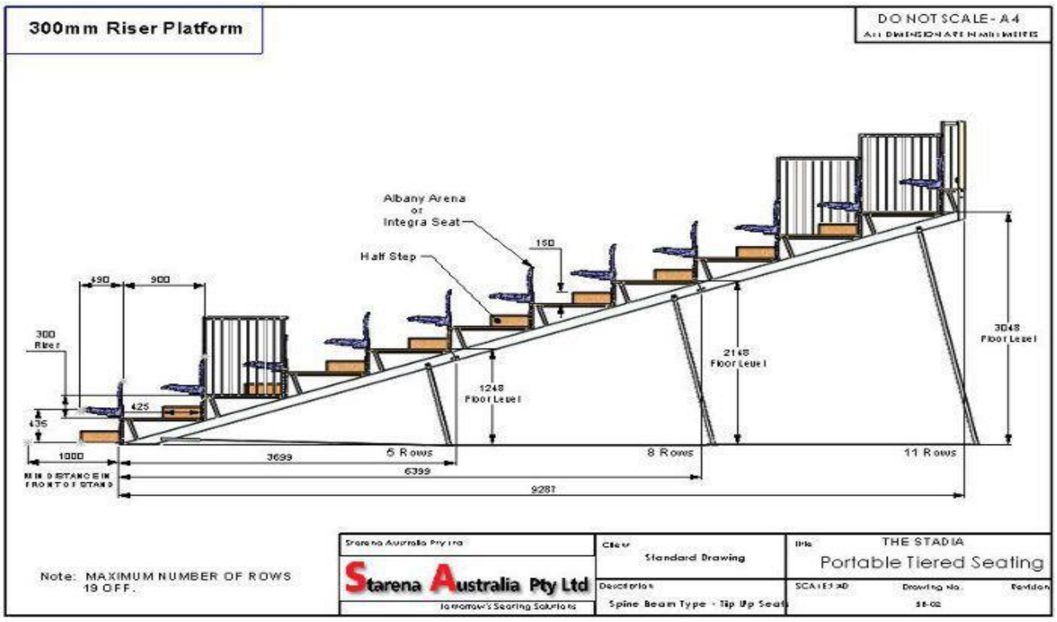


Figure 6.21: Audience Stair Dimensions

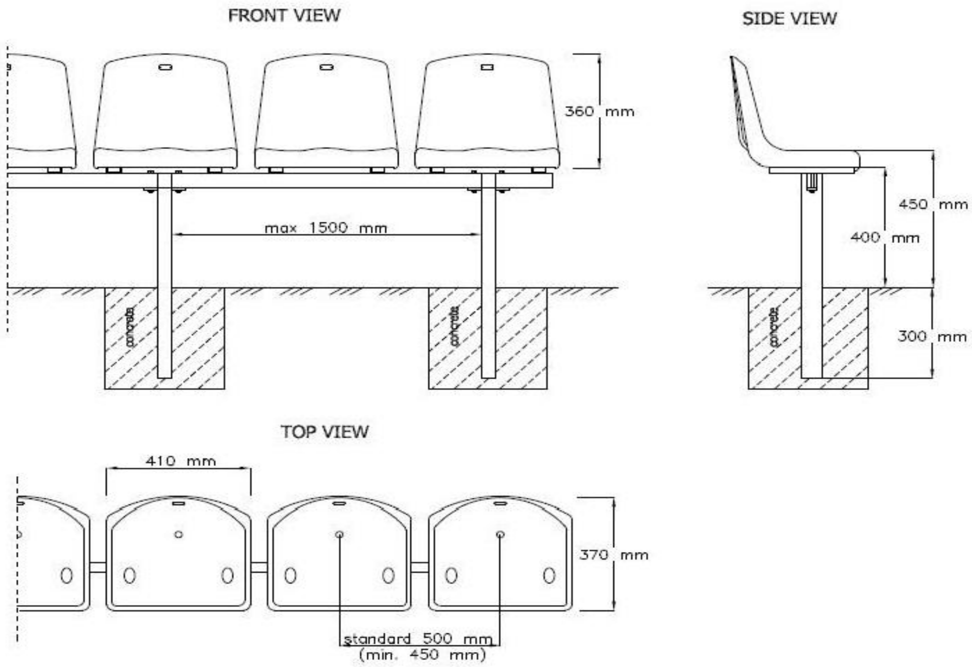


Figure 6.22: Audience Chair Dimensions

To cover a 5000 site, a group of sites block needed. Every block is containing 8 rows and a 14 site for the row. 112 sites for the one block. Two levels of block with a 4m ally separation to allow the audience to move freely. For the separation between two near block is a 2m width stair along the block.

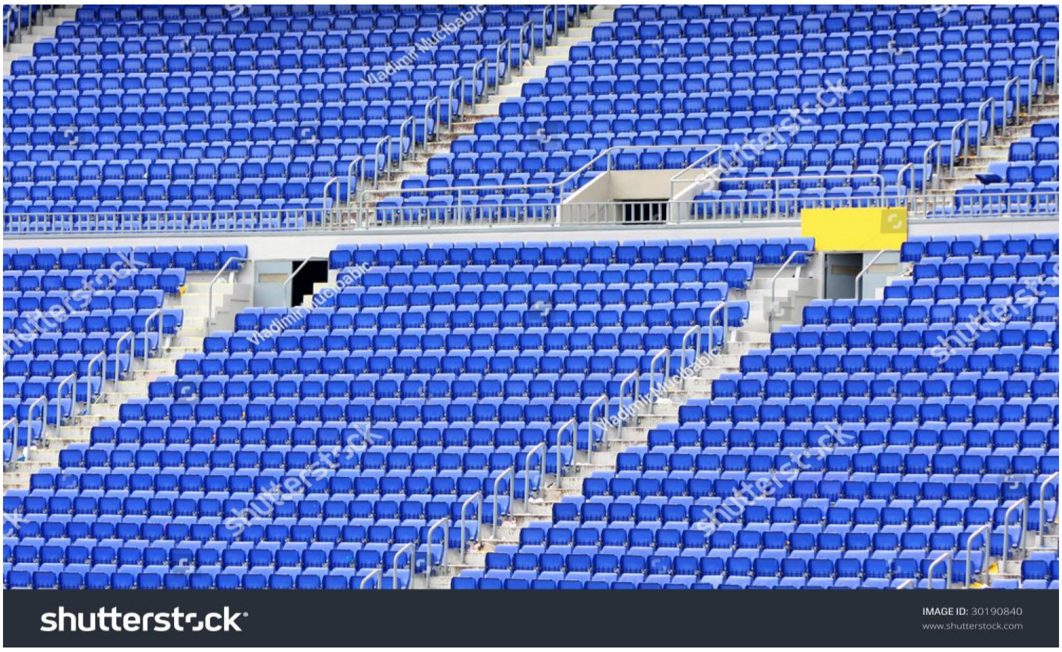


Figure 6.23: Audiance Sites Block

Corners:

In order to design corners, racing line has to be found in them, if the corner is single radius curve, then the racing line will pass the first point and the last point of the corner crossing the apex in between. A geometric method was used to conduct the racing line for these corners, by drawing a circle passes these points. By knowing the radius of the circle, the radius is known, thus the speed at these corners can be calculated, assuming that the friction coefficient of the new asphalt is .3, and the inclination is 5%. The following equation was used to find the speed (Barišić, 2019).

$$R_{min} = \frac{V_p^2}{127\left(f_{Rdop} + q_{max}\right)}$$

Where,

R_{min} – min. horizontal curve radii [m]

V_p – travel speed [km/h]

f_{Rdop} – friction coefficient

q_{max} – max transverse gradient [%]

Figure 6.24: Minimum Radius

The following table contains the characteristics of each corner named, taking consideration the cars will rotate clockwise in the track.

Table 6.6.2: Corners Dimention

	Corner outer radius(m)	Corner width(m)	Corner length (m)	Racing line circle radius (m)	Corner speed (km/h)	Run off (m) (Average)
T1	75.72	15	117.41	126.5	74.99	60
T2	26.9	14	19.3	146	80.56	33
T3	70	14	101.9	270	109.55	40
T4	76.53	14	225.9	74	57.35	55
T5	45	14	126	40.3	42.32	38
T6	55.34	14	190.77	57.5	50.56	50
T7	29.23	14	46.67	51	47.61	48
T8	68.34	14	61.66	200	94.29	30

T9	68.15	14	224.1	66	54.16	40
T10	29.85	14	54.55	53.31	48.68	40
T11	74.68	14	196.73	75	57.74	40

Sections are provided in the Appendix

Maximum number of cars on the track

Based on Appendix O provided by the FIA, the maximum the number of cars allowed to start in an international race based on this equation (FIA, Appendix O, 2021).

N= 0.36 x L x W x T x G (N to be rounded up to the next whole number).

=.36*4.3*12*1.4*1= 26 cars

26 is the maximum number of cars allowed to race at the same time in one event.

This calculation is to avoid the crowded track, which cause accidents and some unfair competition for the racers.

6.6 Parking

6.6.1 Introduction

Ice-skating rink in Provo, Utah studied for a trip generation rate. The study was completed by Brigham Young University. Data were collected from Thursday, March 13, 2014, through Saturday, March 22, 2014. Three consecutive days were proposed for data collection, but problems occurred on Saturday, March 15, 2014, so data were collected again on March 22 for this study. As stated in the proposal, trip generation was counted between the hours of 7 a.m. and 7 pm (chapter, 2014).

6.6.2 Trip Generation Rate

The trip data for the morning peak period, the afternoon peak period, and the peak hour of the generator is shown in Table (6.3).

The data were collected starting at 9 a.m. on Thursday, so the morning peak data were not available for that day. Data about vehicle occupancy was not collected during this study.

Bicycle trip data were also collected as part of this study; the bicycle trip counts proved negligible. Data on pedestrian trips were collected; however, no pedestrians were observed using the two recorded accesses on any day (chapter, 2014).

Table 6.6.3: Parking Collected Data

Thursday (3/13/2014)			Friday (3/14/2014)			Saturday (3/22/2014)		
Entering	Exiting	Total	Entering	Exiting	Total	Entering	Exiting	Total
1028	905	1933	867	723	1590	2154	1949	4103
53.2%	46.8%	100.0%	54.5%	45.5%	100.0%	52.5%	47.5%	100.0%

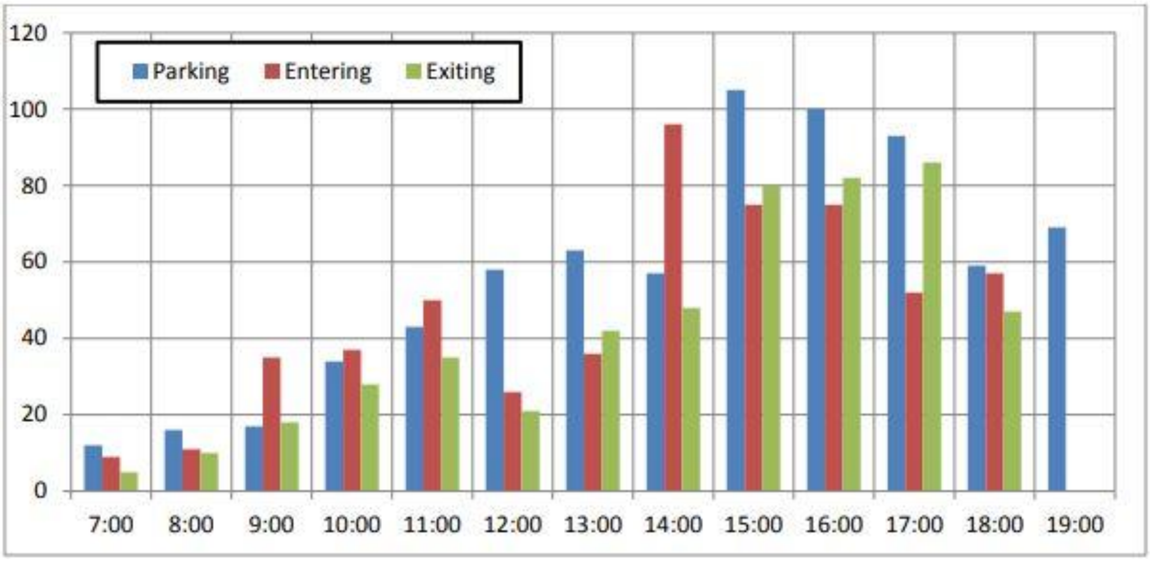


Figure 6.25: Comparison For The Parking Results

Through the study above for a sports arena. the Peak hourly trip rate was 176, and a total entering 2154 persons. The used parking rate was 0.03 - 0.10. Also, for the American obsession with sports, 0.08 is advised. With the 5000-seat needed for the audience a 500-parking lot is required for the arena.

Without mention the parking for employees in the arena; the advice was to have separated parking than the audience one. At every coming event, there are guesses, it’s not a flair to put them at the audience parking, so some lots can be classified only for guesses. Guesses can be from the local region or other countries, like the national referees and advertisement management of a products company.

6.6.3 Parking Spaces

For the parking lot spaces, the AASHTO is considered as it describes the all cases. After a lot of studies, the European copy of the AASHTO advice to diminutions as in Table (6.6.4).

Table 6.6.4: AASHTO Parking Dimentions (Officials, Parking Lots, 2018)

	Euro (m)	American (m)
Length	4.88	5.49
Width	2.44	2.59
Space between other line	6	7.30

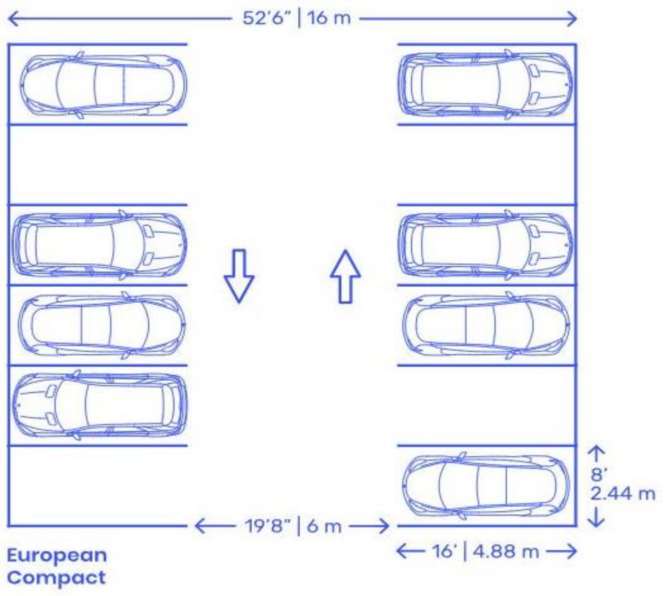


Figure 6.26: AASHTO Parking lot Euro (Officials, Parking Lots, 2018)

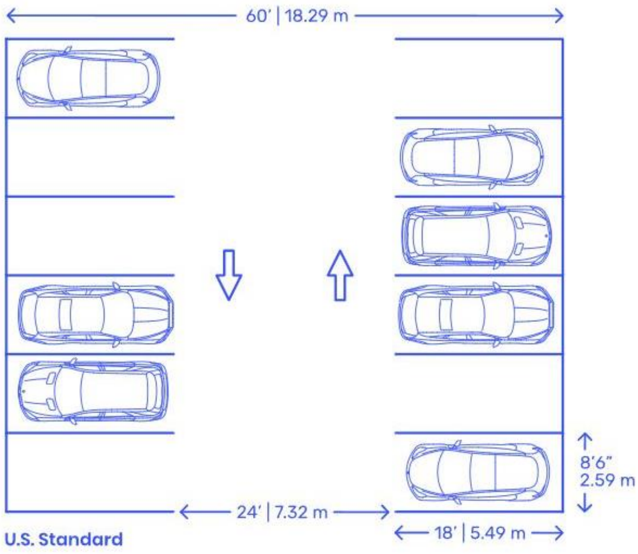


Figure 6.27: AASHTO Parking Lot American (Officials, Parking Lots, 2018)

The parking rate found through the studies was 0.1 vehicle/site. So, as a 5,000-audience is expected, leading to a 500-parking spaces as minimum. A 600-parking lot was designed. Also, a bus lane with a network connection was provided; avoiding the crowded lots and to encourage the people to use the public transportation.

On the other hand, there is a VIP parking. For the special guests and some of the arena workers, manager, safety engineer, referee, presenter of the organizations. 52 parking spaces in the VIP parking with a separated lane are provided.

For the bus lane, a 3.6m width one-way lane is advised, as only the buses will use that lane. Also a roundabout at the end to make a smoother turning after audience get off. Off course, there is a passenger loading lane alongside to the main parking, which can be sued for short parking or long parking Figure 6.28. In a public transportation case, it’s a short parking, just to get the passengers off the bus. In a long parking case, the bus could park until the event ends (Officials, Parking Lots, 2018).

With a 4m width, the passengers can get around freely, without any problems.

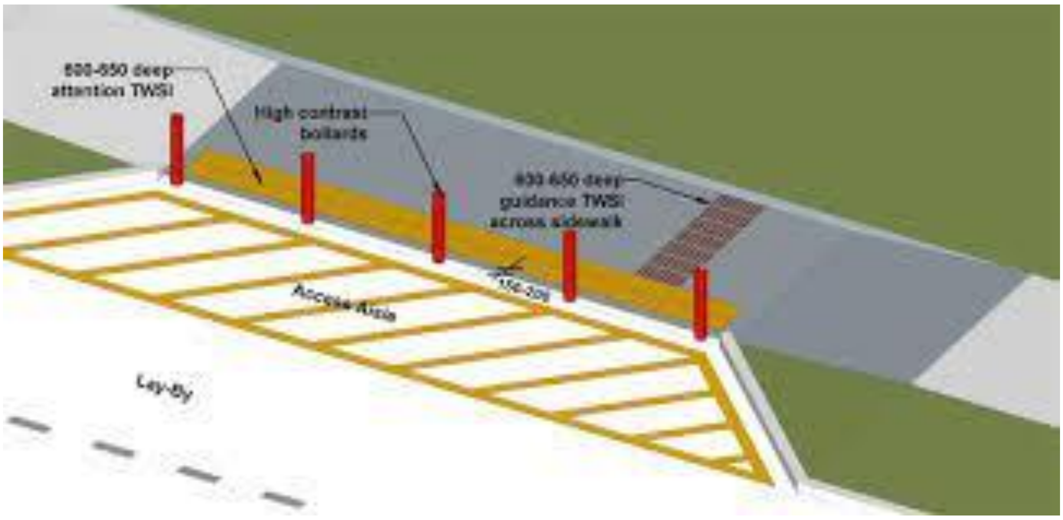


Figure 6.28: Loading Area

See the Appendix

7 RESULTS AND RECOMMENDATIONS

7.1 Summary and Results

The designed circuit includes the basic understanding for this type of industry, and the opportunity of future work. In fact, what was covered is just the shell of what this industry has. The design can be developed to include detailed analysis of racing line along advanced 3D simulation in game engine. Circuit structures were mentioned by the name only such as (racing control room, garages, timing room, etc.). These structures can be designed in details in future work matching the FIA standards.

The project contained a summary for the FIA regulations on design. These regulations and requirement were added to introduce this knowledge for anyone wishes to continue this work, in a way they don't start from zero, as we started this project. The designed track contained 11 single radius corners; all were designed according to AASTHO standards. These corners can be designed differently if a racing line gets conducted using numerical methods.

Unfortunately, due to lack of time, lap times, top speed, and speed at each corner weren't included. This is because of the challenges faced in simulation of the track on AC, as it required better understanding for games and their field, and how they work. About 5000 spectators' seats were also provided, along with more than 500 parking spaces. The movement of traffic was covered using the AutoCAD including implementing changes on the current road to the project site. Furthermore, the track can be used for festivals and celebration in off season times; such actions bring money for the investor. Although, the track wasn't designed for motorcycles, the FIA doesn't prevent such races on the circuit because of the profit they can bring.

7.2 Recommendations

The project shows the size of investment in this industry, and feasibility study that should be made before beginning such a project. Such studies will focus on the popularity of the sport in the country, and predict the attendance for these races in the region. The piece of land that project considers as a study area should be examined and surveyed, the nature of the soil should be clearer for the designers, as well as for elevations on the site. Such studies allow engineers to calculate the excavations and filling on the project, giving more realistic measurements. A detailed bill of quantity should be performed, showcasing everything that the circuit includes.

For any continuation on this work, RTB, KS Editor, and AC programs should be included. The designers should be aware of these programs, and how they help in simulating the circuits and designing them.

Pavement layers of the track road weren't designed. The asphalt, base course, and the subgrade should be designed to endure the load from the racing cars. A traffic study for the area should be conducted to represent the effect of the circuit on the city of Jericho. The drainage system for the circuit should also be designed.

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Appendix

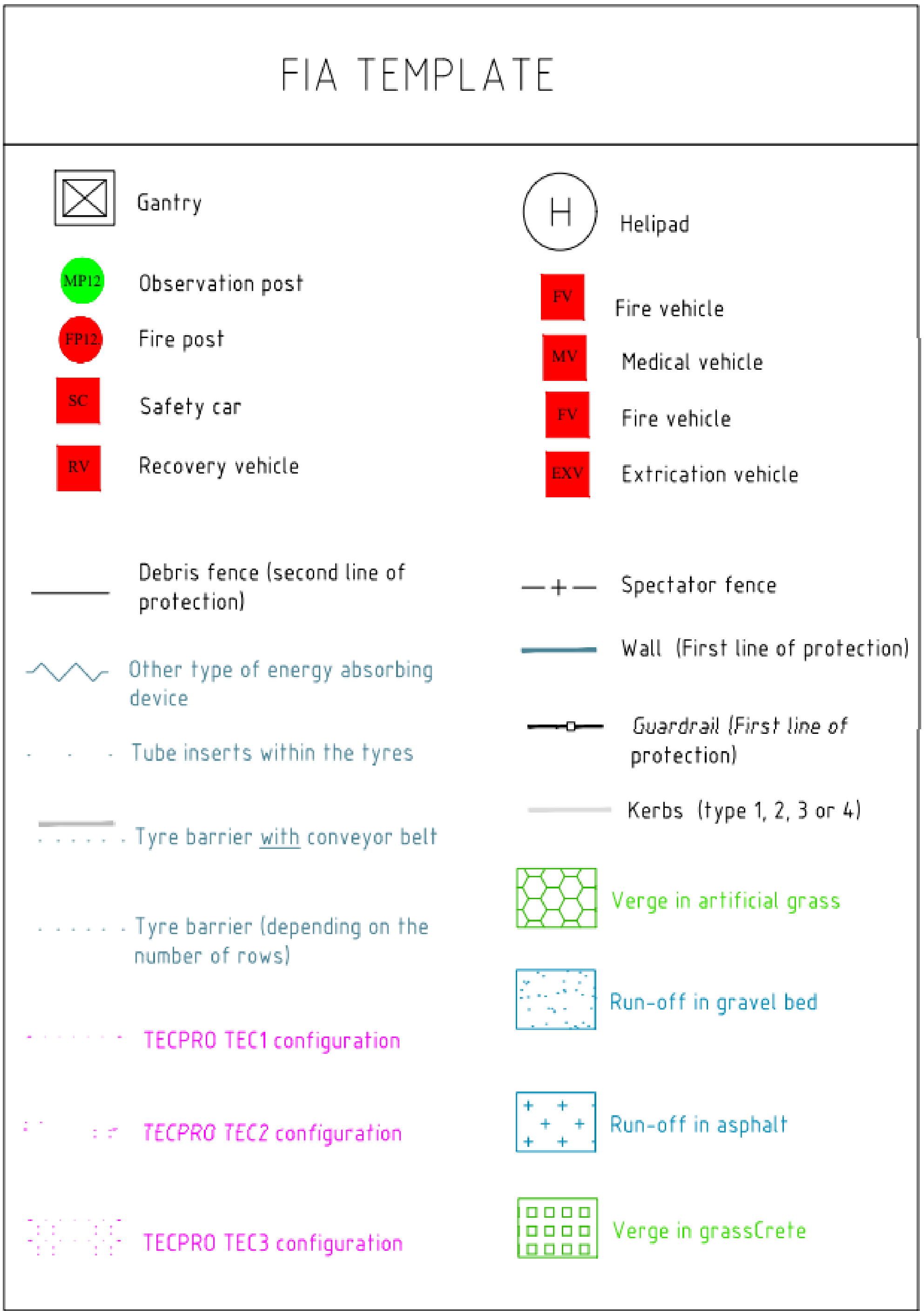

Figure 1: FIA Template

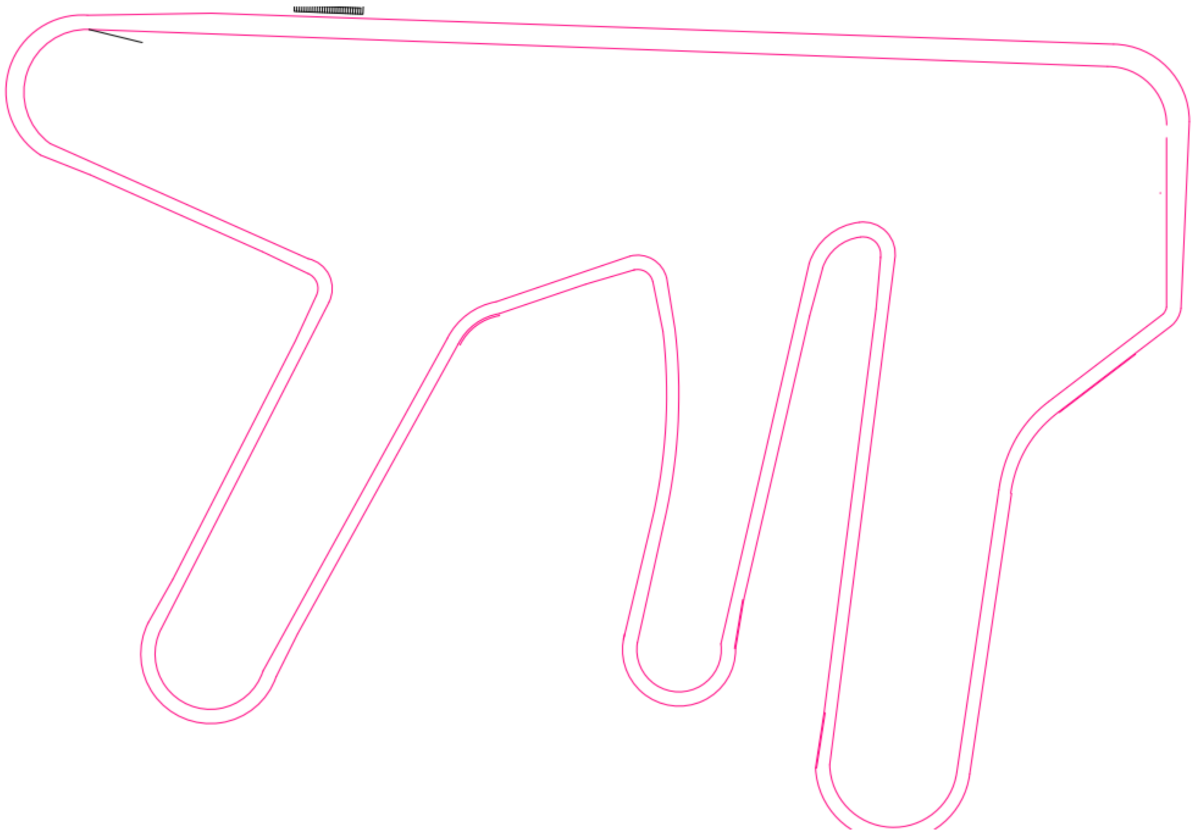

Figure 2: Track Layout

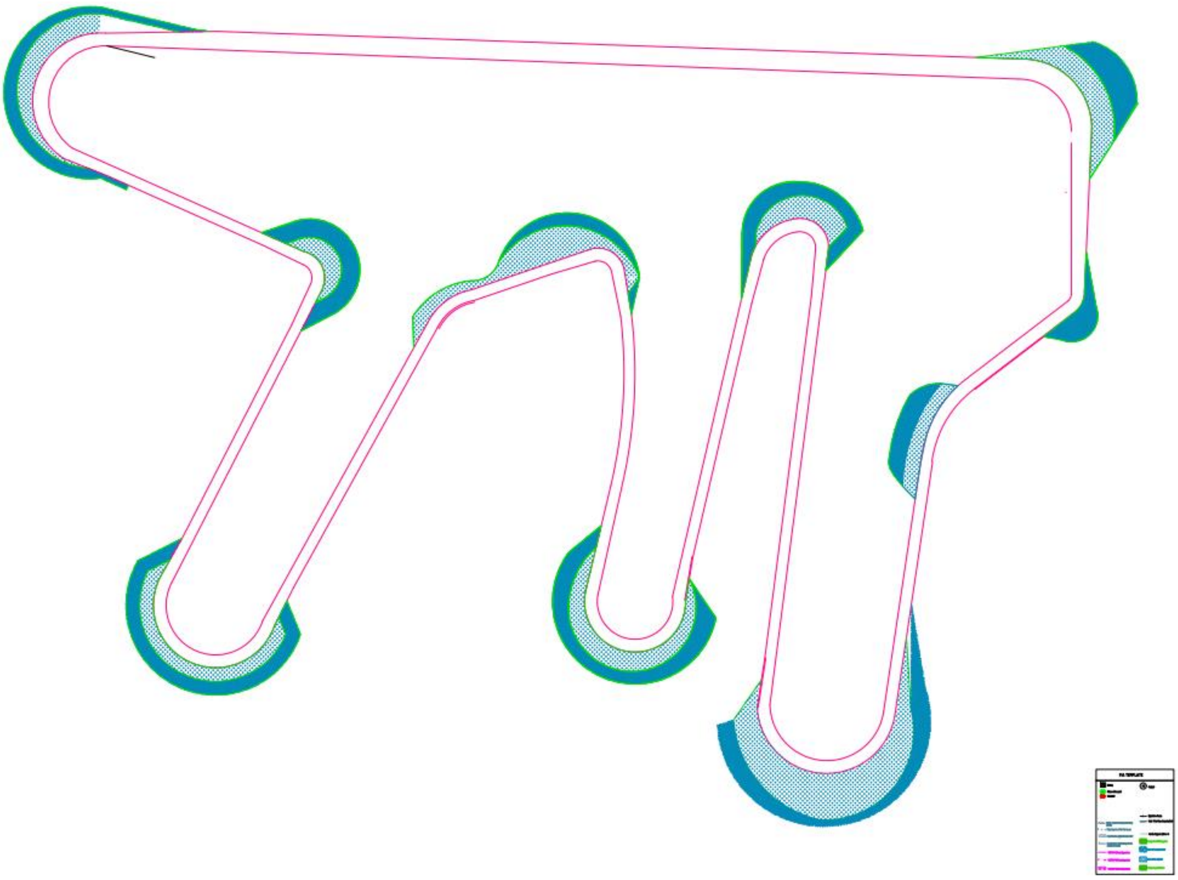

Figure 3: Track Run -Off

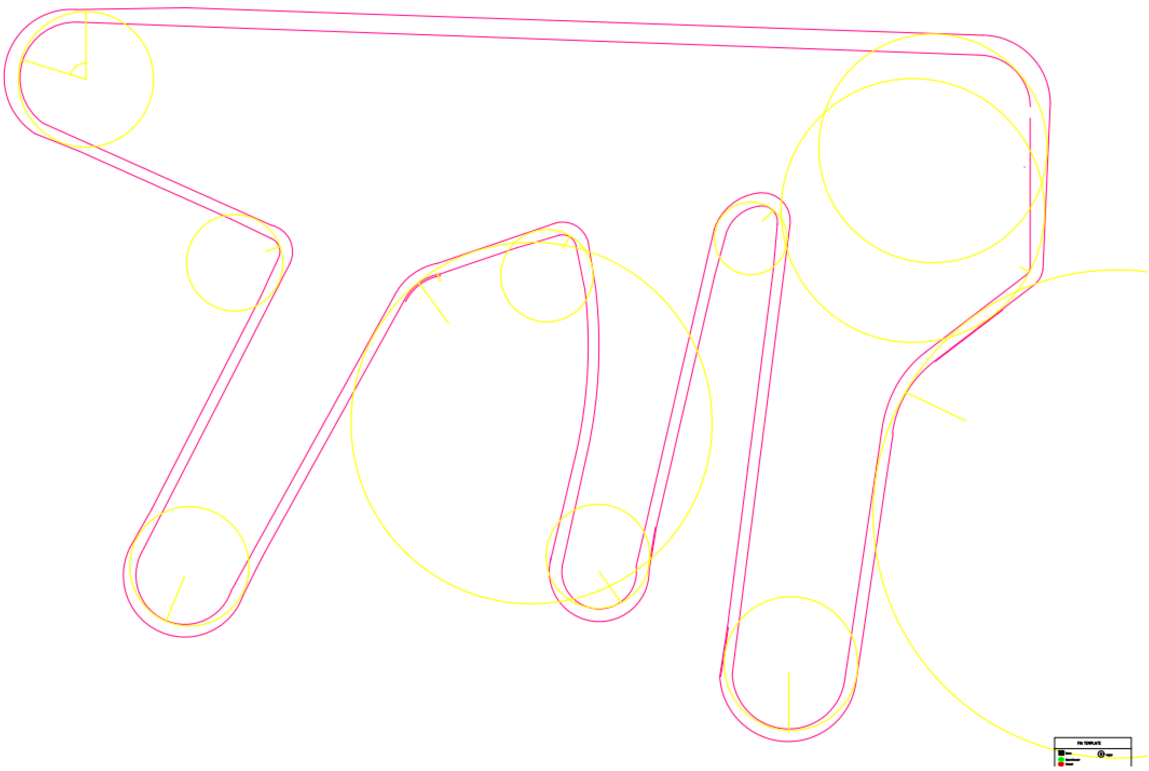

Figure 4: Racing Line Conducting

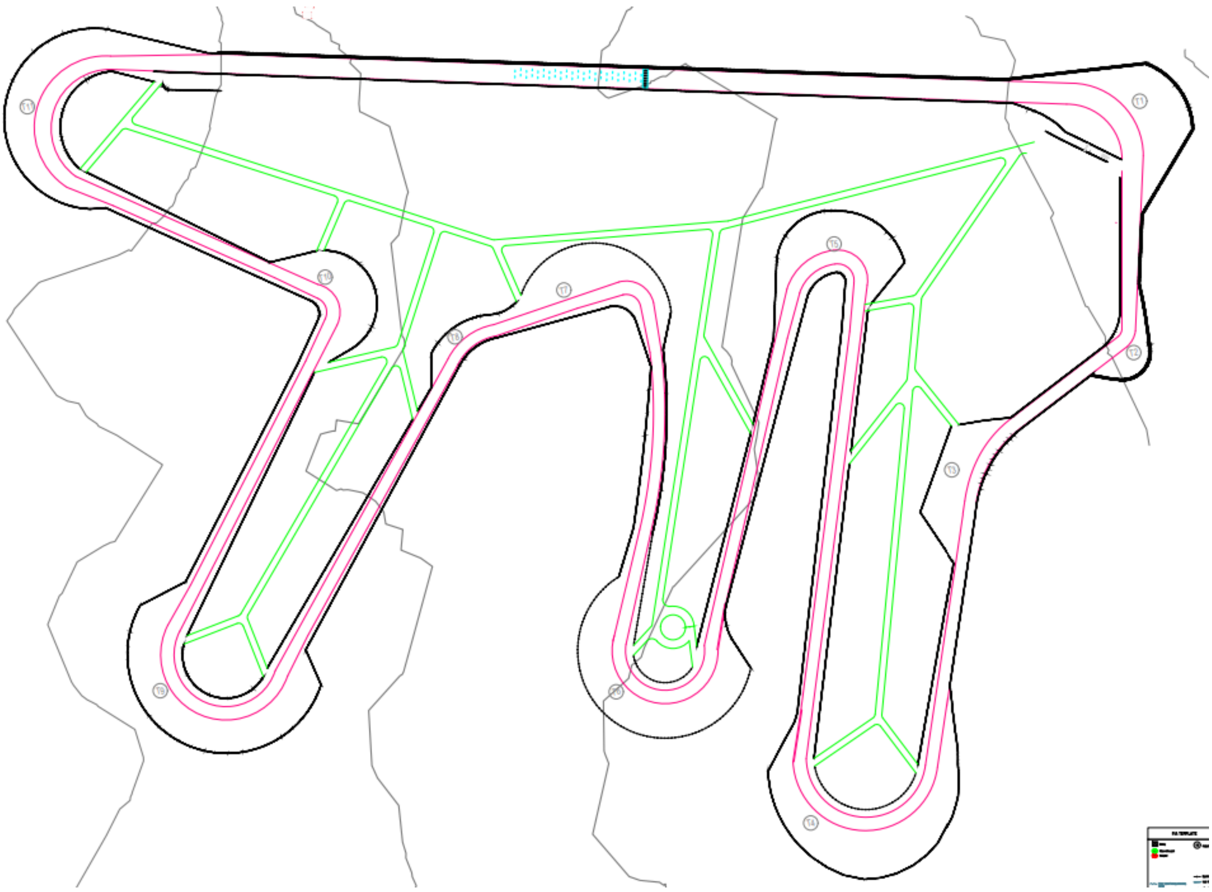

Figure 6: Inner Roads

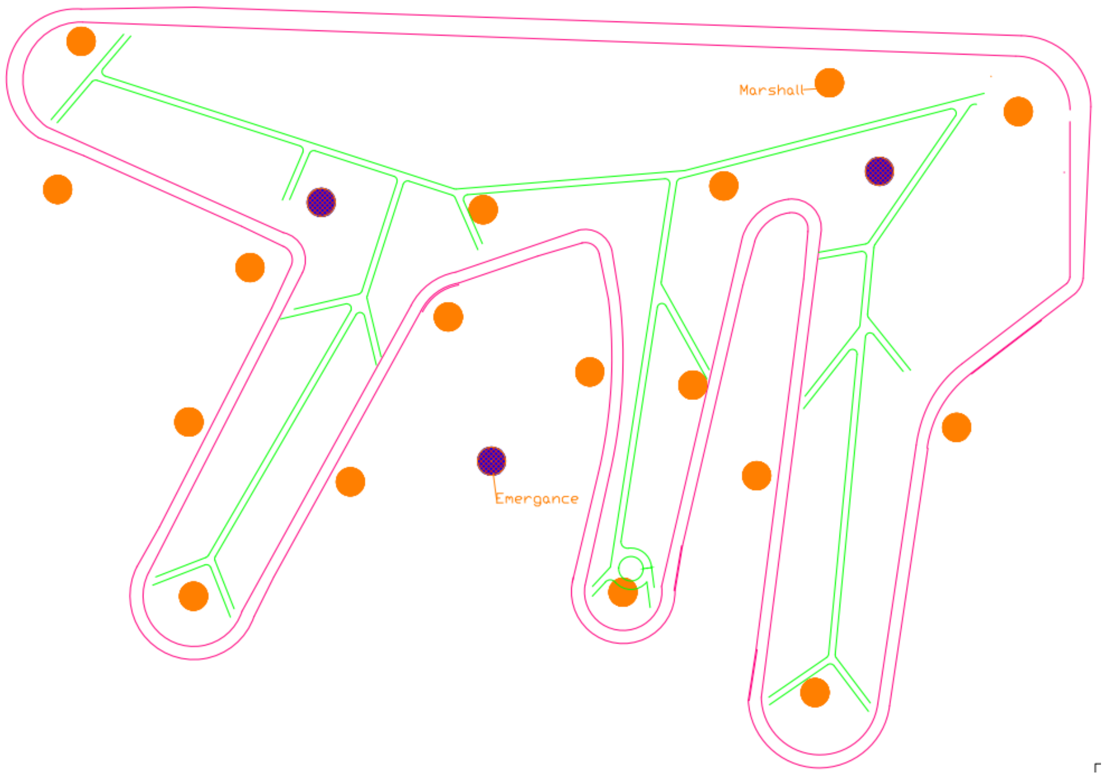

Figure 7: Marshal Posts and Emergency

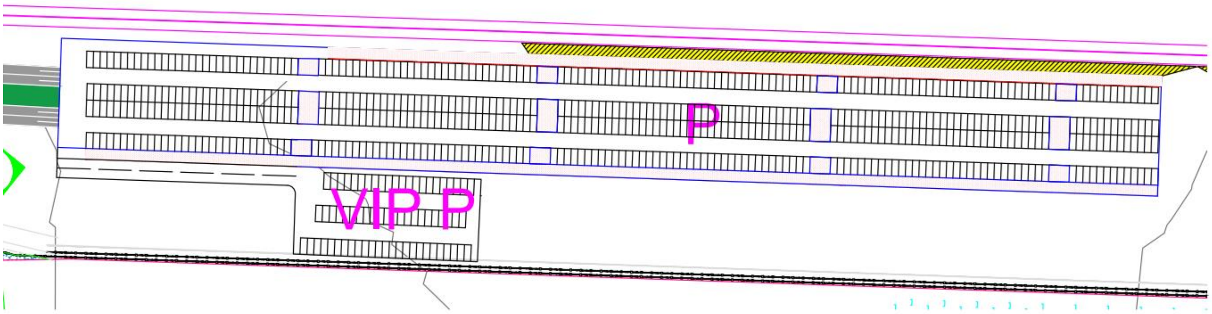

Figure 8: Parking

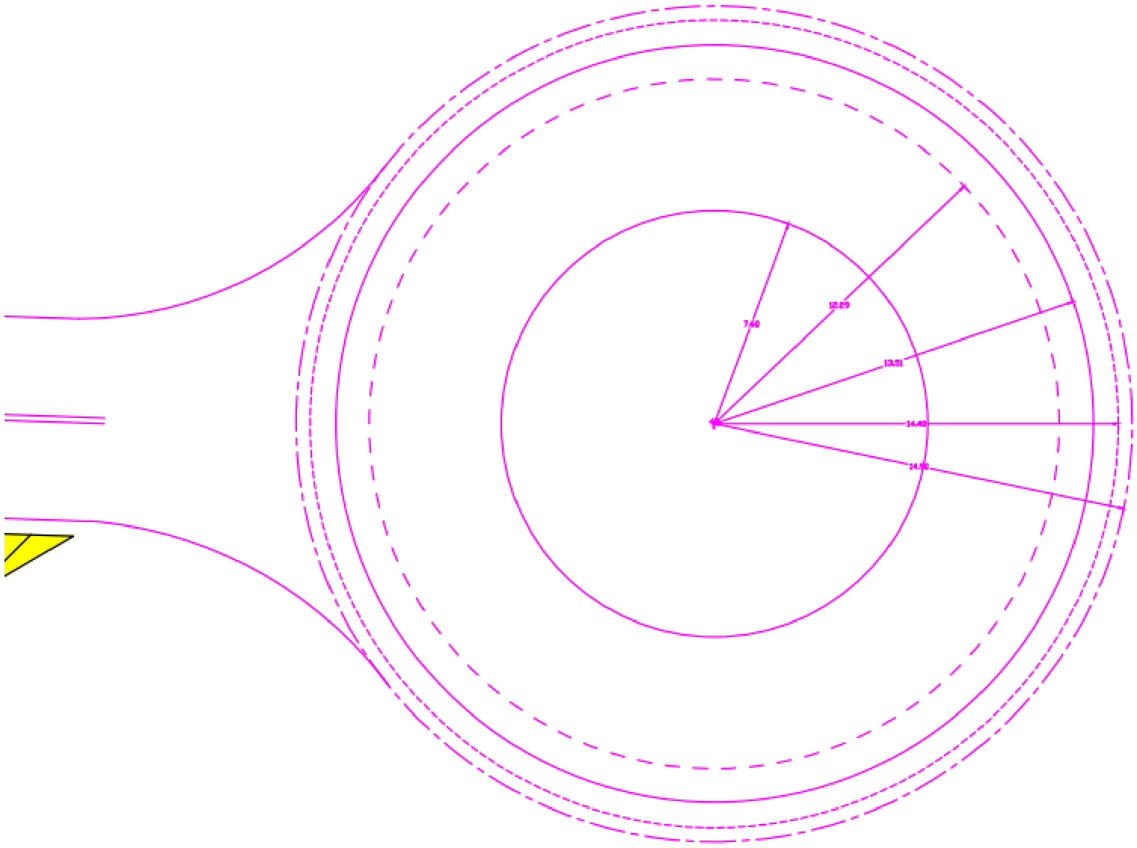

Figure 9: Roundabout

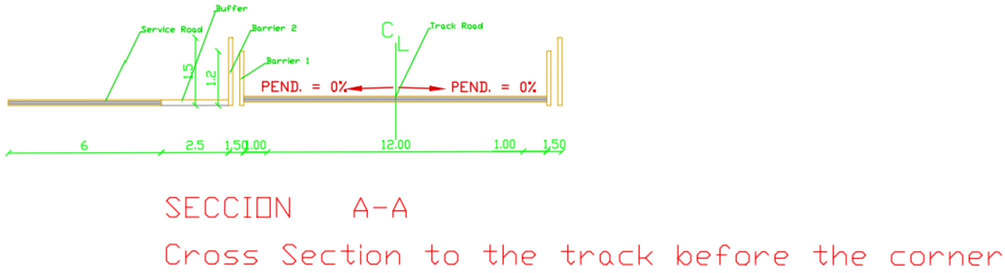

Figure 10: Section A-A

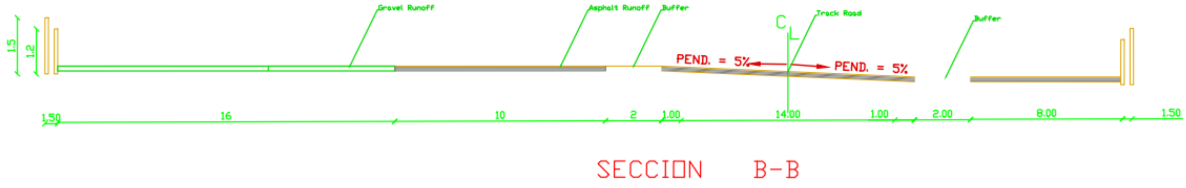

Figure 11: Section B-B

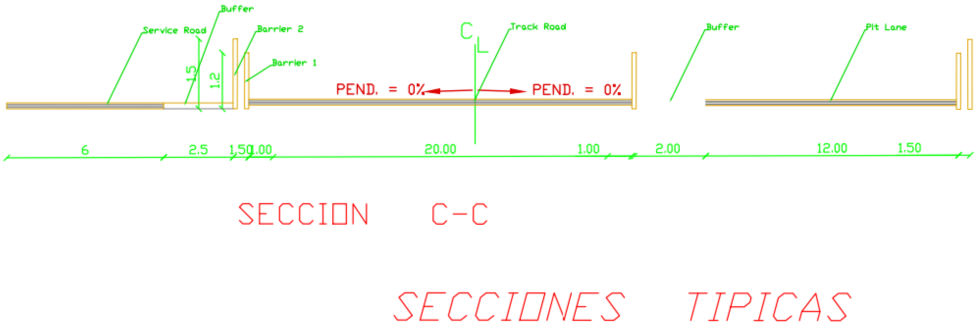

Figure 12: Section C-C

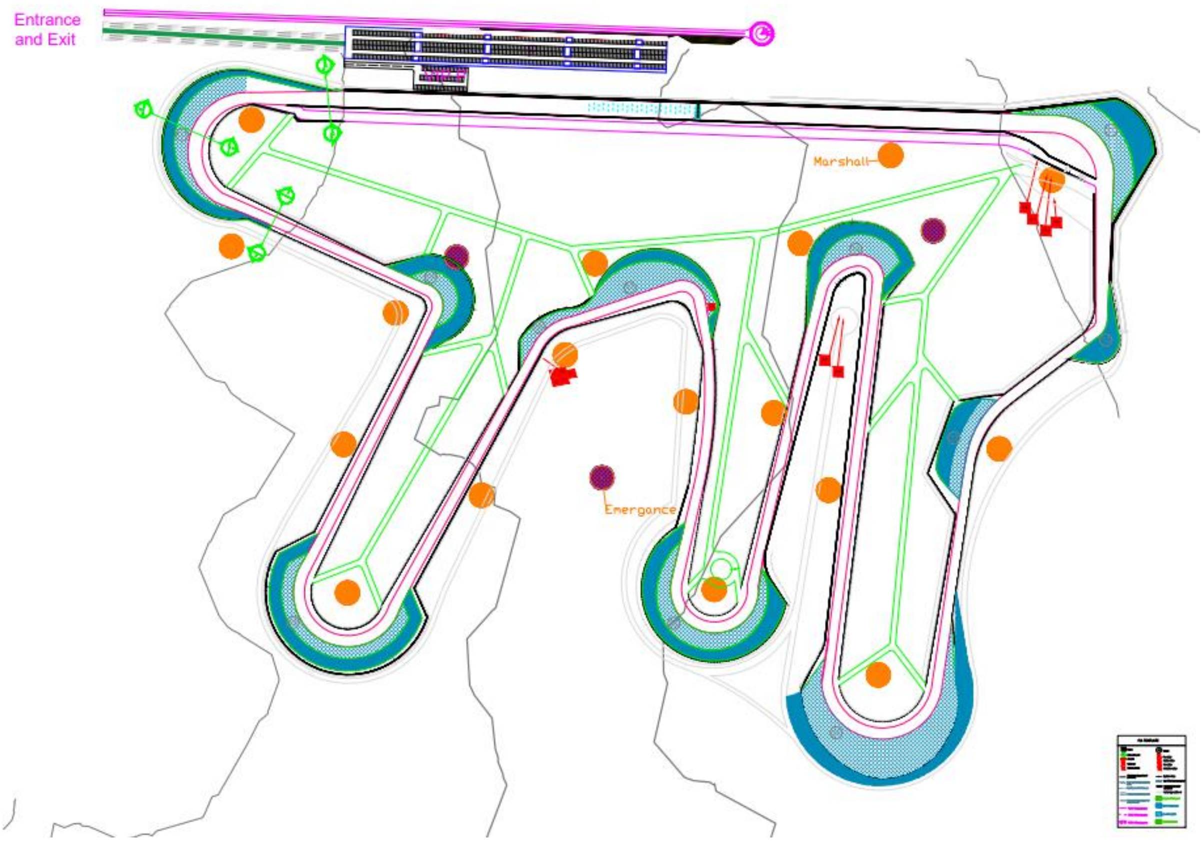

Figure 13: The Circuit