Parking and rest areas

Course Notes: Infrastructure
Urban and Metropolitan Roads

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University Department Section:

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PARKING AND REST AREAS

1. INTRODUCTION

Owning a private vehicle for transportation is now a standard of living throughout the country. In this regard, Italian law requires new buildings to provide at least 1 m2 of parking space for every 10 m3 of construction space.

Furthermore, for several years now, the average household has been shifting toward two vehicles. Everyone wants an additional vehicle, but few make the purchase based on the availability of a garage to store it. This is the common line of thinking, driven by the

There second or the third car leaves the road: yes in inability to find adequate parking spaces, which leads to urban degradation, slow traffic, and the inability to freely use public spaces for other activities (walking, shopping, etc.).

Congestion in urban centers and the need to provide the city with suitable service facilities require strengthening the infrastructure supporting connections, and, above all, parking areas.

2. THE URBAN PLANNING PROBLEM

Vehicle circulation is the essential element for controlling urban traffic.

This is divided into two distinct moments:

- the one in which vehicles move along the roads; the
- one in which vehicles stand still waiting, between one journey and another.

The number of motor vehicles circulating in Italy is over 22 million; since each vehicle requires an average of 25 m2 of parking space, the total surface area allocated to parking areas should be over 1 billion square meters.

Another consideration is that the distribution of time between vehicle movement and parking is heavily skewed toward parking: on average, cars are used for only two hours a day, while the other 22 are stationary. In central city areas, only 10 out of 100 vehicles are in motion, and furthermore, car use as a means of transportation within the city far outweighs all other modes of transportation.

In this context, the greatest concern concerns urban roads, which, as the main category of urban spaces, play a fundamental role in the social, physical, economic, and cultural life of the citizens themselves. For everything to function optimally, since the cross-section of existing roads in historic centers cannot be increased, it is necessary to free these roads from everything other than vehicular traffic.

movement.

Temporary parking spaces (for non-residents) are therefore needed in addition to permanent parking spaces (for residents).
The limited width of the streets in old town centers suggests a classification of needs based on the following scale of priority: ÿ pedestrian transit, possibly in a
protected area (portico, sidewalk); ÿ car transit (perhaps one-way); ÿ temporary
parking for loading and unloading goods; ÿ
parking for residents' and non-residents' cars.

It is therefore necessary to drastically reduce the possibility of parking on the street, that is, to try to encourage residents to seek stable solutions other than parking their cars on public roads.

2.1 The regulatory landscape

In Italy, Ministerial Decree 1444/68 entitled “Mandatory limits on building density, height, distance between buildings and maximum ratios between spaces intended for residential and production settlements and public spaces or spaces reserved for collective activities, public green spaces or parking to be observed for the purposes of the creation of new urban planning instruments or the revision of existing ones, pursuant to art. 17 of Law no. 765 of 6 August 1967” established for the first time the minimum amount of space to be allocated to parking, introducing the obligation to reserve a portion of the surface area of new buildings for parking (building permits issued after 1968).
Table 1 shows the minimum requirements required by Ministerial Decree 1444/68 for areas to be used for parking.

Location		**Parking area (m2)**	Everything is fine
New construction (in addition to the following values)		1	20 m3 of construction
Residential settlements	Zone C	2.5	1 inhabitant
	Zones A and B	1.25	1 inhabitant
	Commercial or managerial	40	100 m2 of gross building area 100 m2 of gross
	Commercial or office space in the area A and B	20	building area
	Industries or similar	10% of the total area designated for public spaces	

Table 1. Minimum allocation of areas to be allocated to parking (DM 144/68)

Subsequently, in 1989, this standard was increased to 1 m2 of parking space for every 10 m3 of building space. Law 122/1989 (the Tognoli Law) moved precisely in this direction, which still allows municipalities to make public spaces available to residents.

To create parking spaces, either above ground or underground. The spirit of the law is to increase parking for residents and reduce high-traffic parking spaces for non-residents, thus establishing a natural rotation of parking for non-residents and avoiding further congestion in the city center (including through the creation of public parking garages, such as multi-story car parks).

2.2 Parking in the urban context Based on their functional level in relation to the urban context and road traffic, parking can be divided into three main categories:

- terminal car parks;
- interchange car parks;
- rotating car parks.

Terminal car parks are used for very long-term parking (serving residences, offices, commercial, tourist and cultural centres).

Park and ride facilities, located on the outskirts of the city center, serve as interchange hubs within the urban fabric (subway, train, bus terminals, airport, port, etc.), or on the outskirts of the historic center. They serve the latter, encouraging and enabling the use of public transportation within the older urban area. This way, users coming from major traffic routes should find parking on the edge of the historic area and then leave their cars to go to work or to run errands within the city center, where, typically, a city's most important public and private offices are still located.

Rotating parking spaces are intended for users who make short stops, both within the historic urban area and near service activities such as commercial, cultural, and tertiary sectors.

To gain a comprehensive understanding of the relationship between parking areas and the area in which they are located, and to analyze the overall impact of car parking on the overall structure of urban mobility, we must first examine the two main activities that characterize parking. These two activities are stopping and parking.

Parking spaces stop are the most common type found in most cities. In their simplest form, they are located along sections of the roadway, adjacent to the sidewalk, and reserved for stationary vehicles. They can, although less frequently, be recessed into the sidewalk.

The width of stopping spaces may be limited to 2.00 m for passenger car traffic only, and may reach a maximum of 3.00 m for heavy traffic. To determine the length of the stopping space, the space required for manoeuvring must be taken into account.
approach and departure.

Two different types of stopping spaces can be distinguished: ÿ a typology which provides for a distance between the vehicles, such as to allow each of them the approach and the departure with direct maneuver;

ÿ A type of parking that requires sufficient spacing between vehicles to allow the roadway to become obstructed during entry and exit maneuvers. It is good practice to plan this type of parking away from intersections or areas of heavy traffic, as the traffic itself is made more difficult by maneuvering vehicles.

The areas of stopover These are areas where traffic regulations, parking spaces and lanes, and maximum parking times are clearly marked. They may be located at the edge of the roadway or in parking areas, but in any case, in areas designated for actual parking.

On the road there are:

- parking lanes on the carriageway itself, with vehicles parked in rows parallel to the traffic;
- parking bays recessed into the pavements, with vehicles lined up in the direction of the traffic;
- lateral parking areas where vehicles are placed orthogonally or at an angle to the traffic.

In the yards there are:

- parking spaces divided into stalls;
- distribution aisles.

The maximum parking space availability is reached when an arriving user finds more than one free space to park their vehicle. Parking needs are met based on vehicle turnover when, during peak periods, at least one vacant space is always available for each arriving vehicle.

The variables affecting parking are of various types and involve the type and reason for parking, current and future demand, current supply, irregular parking, fare costs, parking times, management costs and distances to be covered on foot.

Regardless of the type of parking you want to create, you must pay particular attention to the following elements:

- examination of the users with the identification of the aforementioned salient characteristics;
- inventory of available parking spaces and knowledge of their level of use (sometimes greater benefits can be gained from the restoration or reorganization of an existing parking lot than from a new construction);
- quantification of parking demand and needs (for this purpose, it is essential to record traffic flows entering and exiting all access roads to the area in question);

• localization;

• estimate of financing, management costs, and potential income.

Furthermore, in addition to the parking space, it is necessary to ensure an adequate access network to the parking lot and to identify any time limits for using the parking lot itself.

The construction of an area or building used for parking can take place through two types of distribution, depending on the size and shape of the area to be used for parking: horizontal development (surface, ground-level,

or level parking); vertical development (underground, elevated, or mixed parking).

Among the vertically developed car parks there

garages to ramps divided into:

are: 1) • one-way straight ramps (on opposite sides of the parking level, on the same side of the parking level, between staggered levels); • two-way

straight ramps (on opposite sides of the parking level, on the same side of the parking deck, between staggered floors);

• one-way helical ramps (continuous: overlapping or concentric; discontinuous: separate and overlapping);

• with two-way helical ramps (continuous; discontinuous and overlapping); 2) •

mechanical garages or parking garage divided into:

automated (with fixed stall, with mobile stall, mixed) • semi-

automatic (with central goods lift, with stall elevator, with platforms translating, mixed with stacker crane).

Ground-level exploitation of the areas is the most economical in terms of system and maintenance costs, but it is not very convenient in terms of land use.

On the other hand, underground construction, although justified from the point of view of the exploitation of the surface area, is more costly in terms of construction, involving not only excavation works but also waterproofing works which increase the costs.

significantly lower costs.

The parking lot that appears to be the most rational from the standpoint of space utilization and costs is the elevated one, which, however, presents the not insignificant problem of having to fit in like a new building among the existing ones (this is often very difficult in urban centers).

3. ARCHITECTURAL TYPES OF PARKING

In order to optimize the design and construction of spaces intended for the storage or simply parking of vehicles, it is of fundamental importance to analyze those which are the types of construction of the single parking space that descends from the overall dimensions of the car itself (Fig. 1) and the relative maneuvering spaces.

Figure 1. Vehicle footprint in the design phase of a parking

The angle of inclination of the parking space with respect to the direction of travel of the access lane may be 0° (ribbon parking spaces, parallel to the direction of travel of the access lane); 90° (comb parking spaces, perpendicular to the direction of travel of the access lane); 30°, 45° or 60° - other angles are also permitted if necessary (sawtooth parking spaces, inclined in various ways with respect to the direction of travel of the access lane) (Fig. 2).

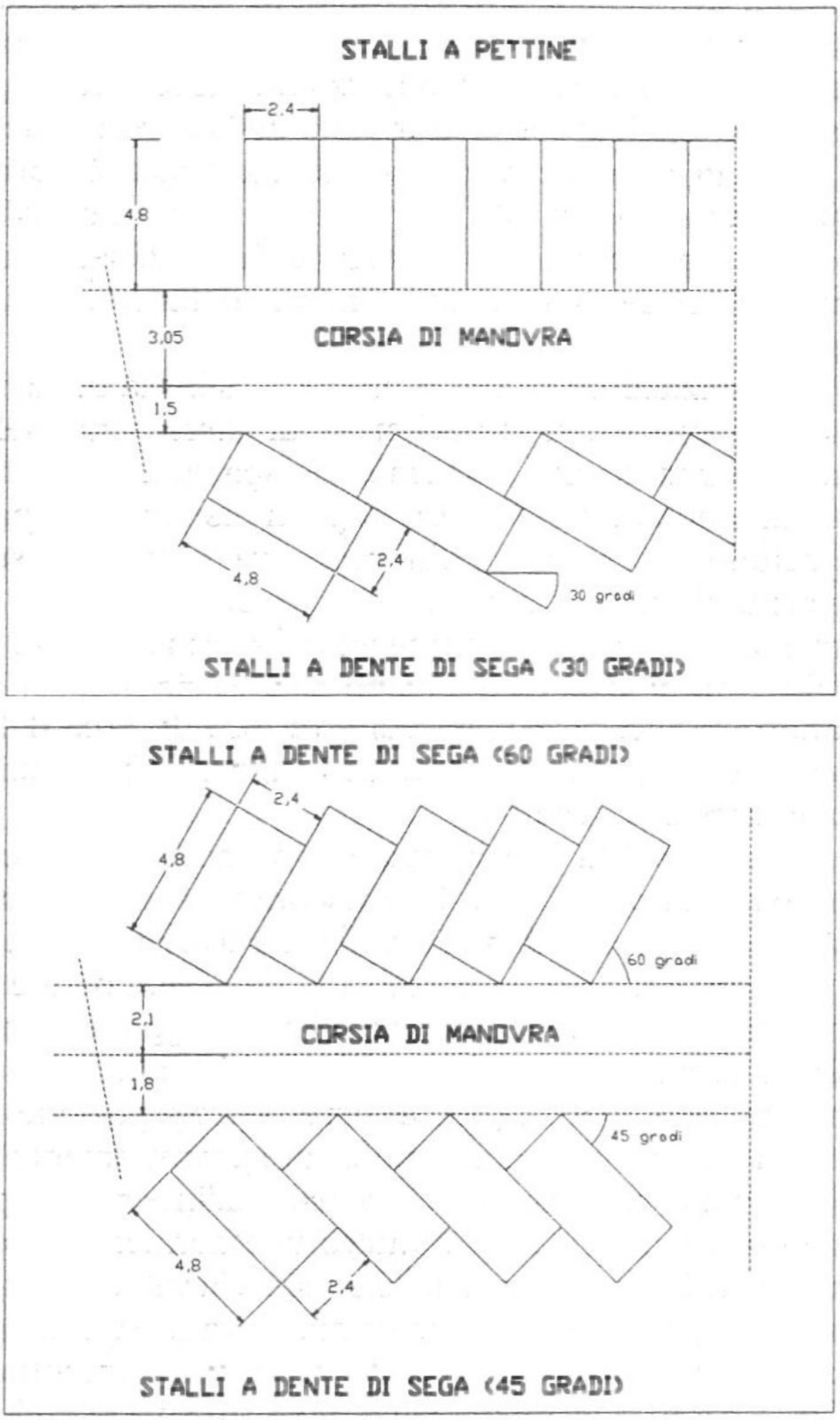


Figure 2. Minimum space requirements to the parking area to comb and sawtooth

These differences allow for architectural changes to the parking deck design, saving space while maintaining the same number of cars or increasing the number of available spaces while maintaining the same usable space. The main differences between the above-mentioned types, given the same number of parking spaces, are:

- total parking space: the most economical parking space in terms of required space is undoubtedly the comb-type parking lot, followed by the belt-type parking lot, which requires approximately 25% more space. Sawtooth parking lots have a percentage gap between them of approximately 10% and take up less space the greater the angle of inclination with respect to the access lane;
- speed and ease of maneuvering, i.e., how one enters and exits the parking space. It has been found that the parking space perpendicular to the direction of travel within the lane is the most problematic in terms of maneuvering and therefore usage times; in this sense, the most functional parking spaces are undoubtedly the sawtooth ones (Fig. 3).

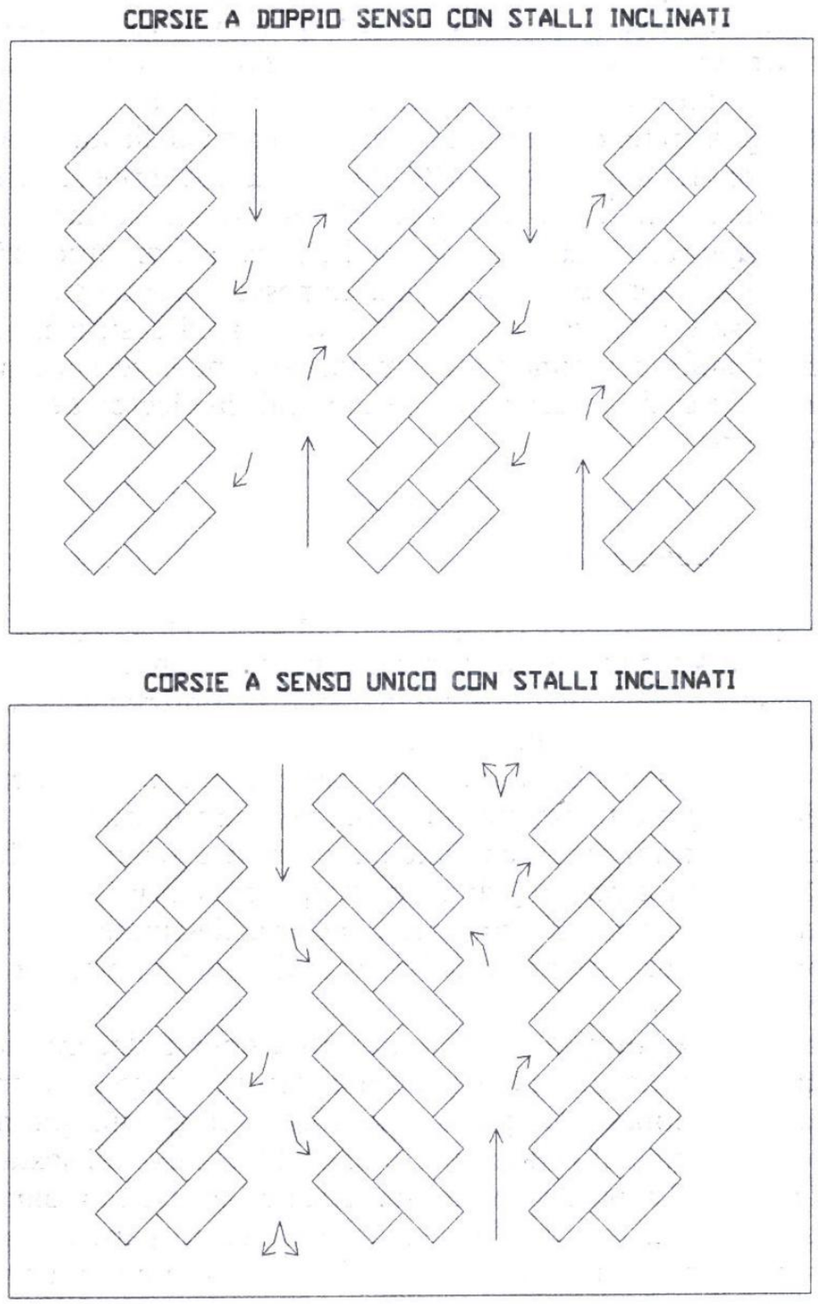


Figure 3. Lane layout one-way AEA two-way traffic in parking lots with inclined stalls

A key element of proper parking design is the ability to analyze and correctly design the space allocated for vehicle circulation within the parking decks. Parking dynamics are not influenced by the length of the lanes and the speed at which vehicles travel, but rather by the percentage of reversing. Consider that in the case of a one-way lane, this percentage is approximately 30% for a 90° parking space and approximately 10% for a 70° parking space. Inclined parking spaces are most effective if the direction of traffic is such that it helps the vehicle enter the vacant space in a forward direction.

Among the various types of inclined parking spaces, herringbone parking requires a longer search time than finding a space when parking with the front bumpers of the cars facing each other. Furthermore, in herringbone parking, the front bumpers of the cars collide with the side of the car opposite, creating the potential for greater damage from accidental contact.
The longer time is due to the fact that the traffic lanes where the parking spaces are arranged in a herringbone pattern must necessarily be one-way, while in other cases, including those with parking spaces perpendicular to the lane, they can be two-way, facilitating circulation and therefore the search for a free parking space.

3.1 Ground-level parking

It is of fundamental importance to screen the parking area as much as possible or in any case create a psychological separation, screening the areas intended for the circulation of cars and pedestrians from those intended for vehicle parking.
Separation can occur through naturalistic decorative elements such as hedges, low walls, depressions in the ground, simply by changing the paving, or in any other way to create a psychological separation between the parking area and the traffic. This screening can be a psychological rather than physical barrier, filled partially—allowing only a glimpse of the cars or allowing a wide view—or completely.

Within the parking lot, the layout of the parking spaces relative to the traffic lanes can be marked in various ways (Fig. 4 and Fig. 5); the real constraint for these parking space markings is that they must be maintained over time. The concrete paving of the parking lot access roads can be replaced with alternative materials that allow for color and material combinations that enhance the architectural value of the parking lot's interior. Alternative materials include rough or colored concrete, prefabricated concrete blocks of various colors, interlocking concrete paving, split stone, river pebbles, gravel, frost-resistant bricks, grass, and plants in general.

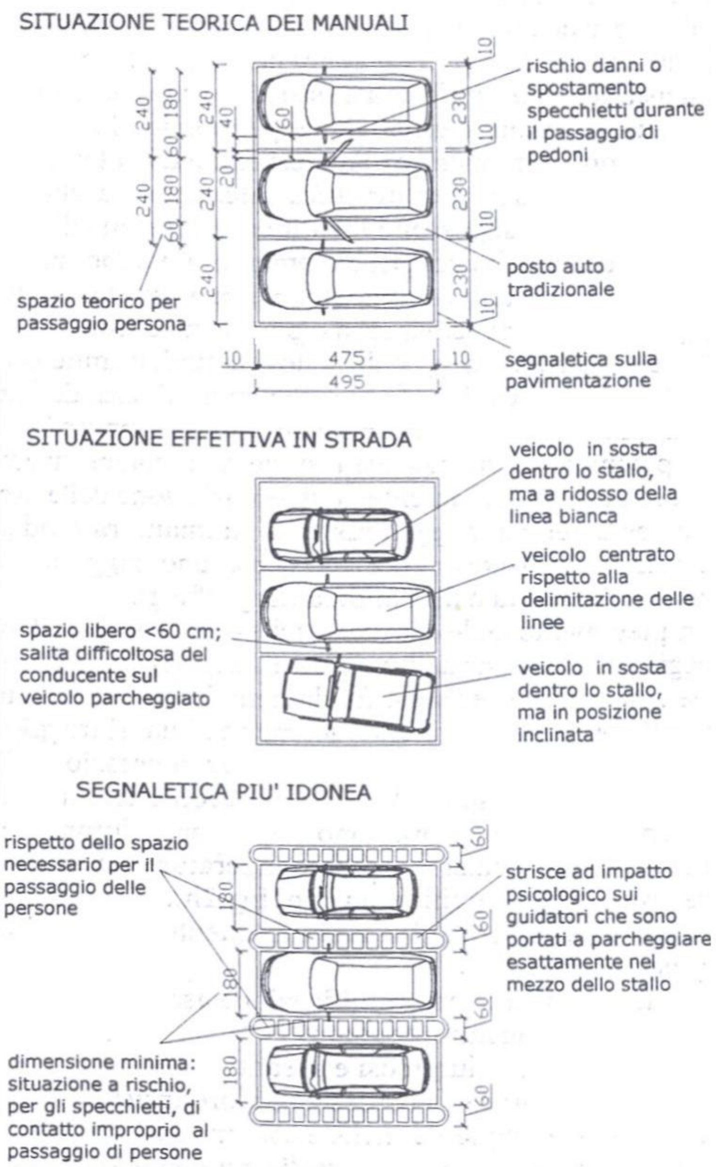


Figure 4. Possible road signs or inside the garage of the various parking spaces

Figure 5. more suitable for more comfortable parking spaces Theoretical situation

The dividing lines between the parking spaces can be achieved by coloring the asphalt or concrete surface, using the hot application of a colored plastic material, or by inserting blocks or stones of different colors into the pavement, in order to visibly differentiate the areas. For parking in

surface parking for buses, as these are special means of transport, specific parking and manoeuvring spaces can be suggested (Fig. 6 and Fig. 7).

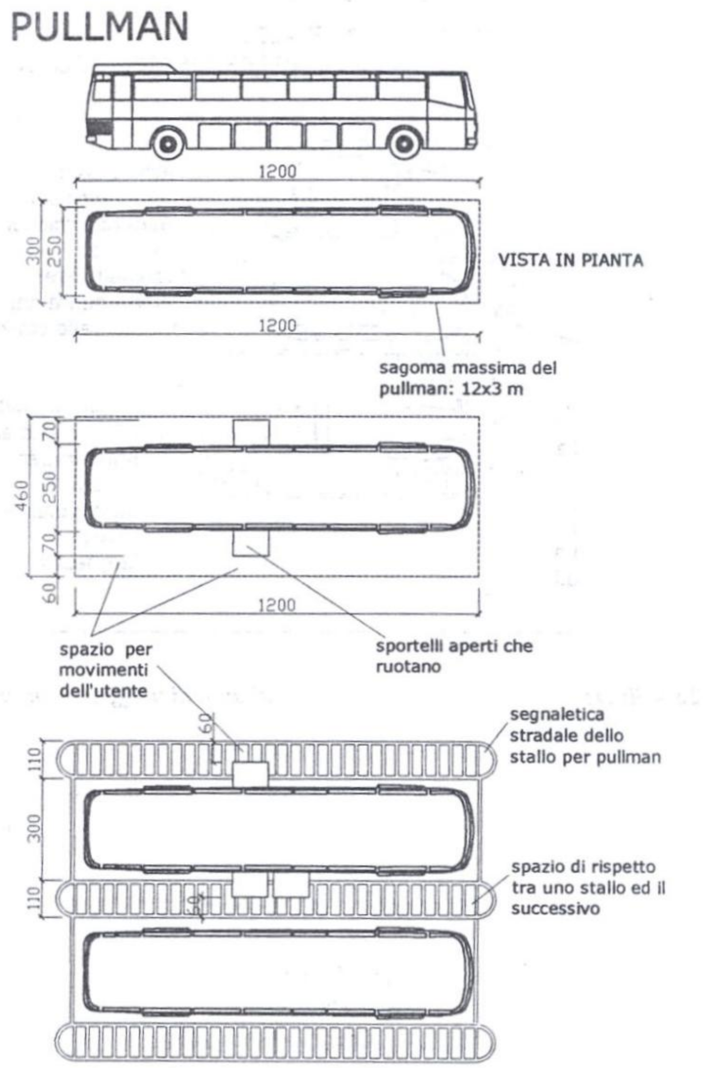


Figure 6. Encumbrance of a bus phase of being designed a parking

To complete the features that an outdoor parking lot must possess, the importance of greenery should not be forgotten; trees are essential for masking cars, for maintaining the microclimate (filtering the gaseous substances emitted by vehicles), for creating movement (plants are changing and living elements and change the appearance of the space where they are positioned throughout the year), for attenuating summer temperatures and as chromatic and architectural barriers (Fig. 8).

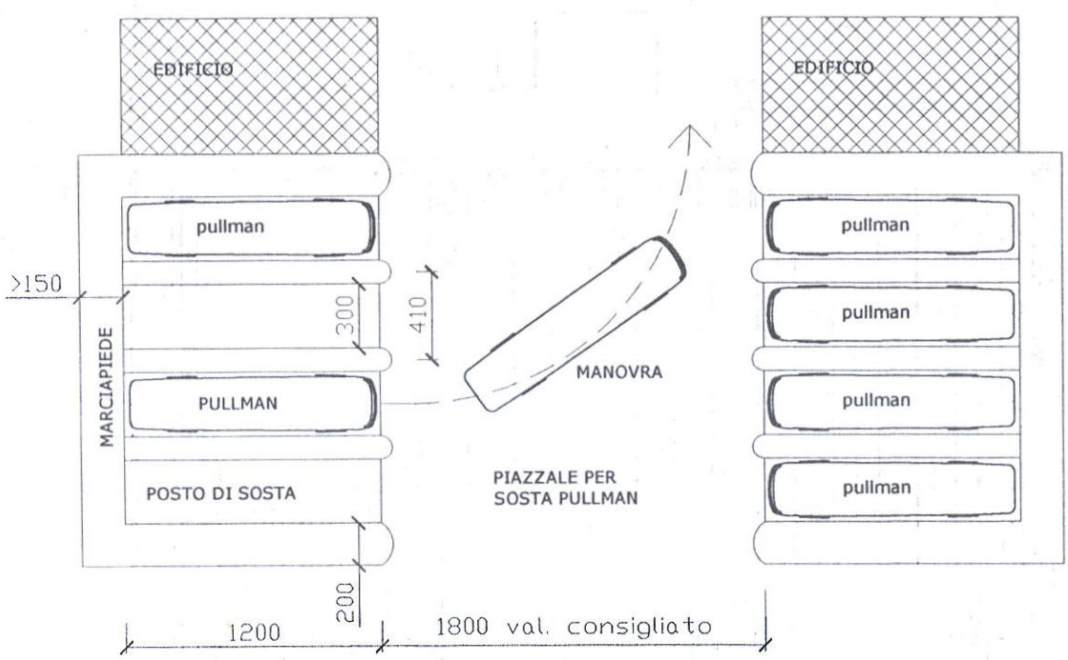


Figure 7. Outdoor parking for buses

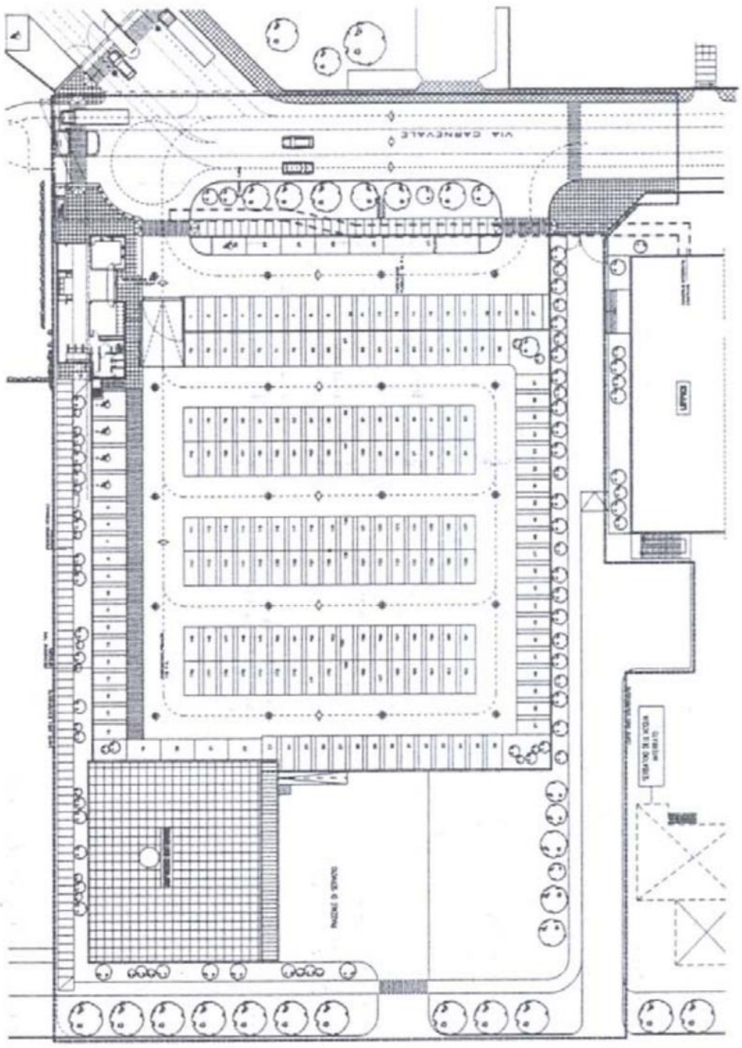


Figure 8. Parking project the Roche plant at ground level near Segrate (Milan)

In particularly hot areas, surface parking can often be covered with simple, slender structures (real canopies) that have a significant architectural impact on the surrounding environment. In this regard, it is crucial to choose the materials for these structures to match the characteristics of the location and, above all, to convey the impression of a construction and not simply a shelter from the elements with no architectural significance. The roofing created in these cases should provide a slightly larger footprint than a typical parking space and a limited height (generally no more than 2.10 m), thus reducing environmental impact.

3.2 Parking for disabled users

When designing a parking area for vehicles, whether a garage or an open-air parking lot, special attention must be paid to disabled users, i.e., users with mobility difficulties. In this regard, Ministerial Decree No. 236 of June 14, 1989 (concerning the requirements for overcoming and eliminating architectural barriers) and subsequently Presidential Decree No. 503 of September 16, 1996, provide specific guidelines on minimum parking spaces for these users' vehicles.

In summary, the decrees state the following:

In buildings open to the public, one disabled parking space must be provided for every 50 spaces, or a fraction
thereof; this parking space must be at least 3.20 m wide and must be reserved free of charge for disabled persons; this space must be appropriately connected to the sidewalk or pedestrian path, which must in turn comply with the requirements of the two decrees (Fig. 9); for reserved parking spaces arranged parallel to the direction of travel, the space must
be long enough to allow a wheelchair user to pass between one vehicle and another; the requirement is considered satisfied if the parking space is at least 6 m long (Fig. 10); in this situation, the disabled parking space may maintain a width equal to that of regular parking spaces.

From these first points it can be deduced that the measurement of 3.20 m (minimum measurement that can be increased at the designer's discretion) derives from an evaluation of the vehicle's overall dimensions of approximately 170 cm, alongside an adjacent space of 150 cm necessary for manoeuvring a wheelchair (and obviously the vehicle itself).

The legislative decrees also highlight the following requirements:

in all cases, disabled parking spaces must be appropriately marked, located near the lifting device, and positioned so that in an emergency, a safe static area or accessible escape route can be quickly reached; vehicle and/or pedestrian ramps must be equipped with handrails;

The maximum transverse slope of the parking lot must not exceed 5% (otherwise, additional specific requirements, omitted here, must be complied with); for outdoor, surface-level parking lots, reserved parking spaces, appropriately marked, must be positioned adjacent to pedestrian walkways and close to the entrance to the building or equipment for which they are intended; parking spaces must be marked and demarcated using yellow lines and a wheelchair user symbol on the pavement; it is preferable to provide a roof over reserved parking spaces for disabled people to facilitate the transfer of wheelchair users in adverse weather conditions.

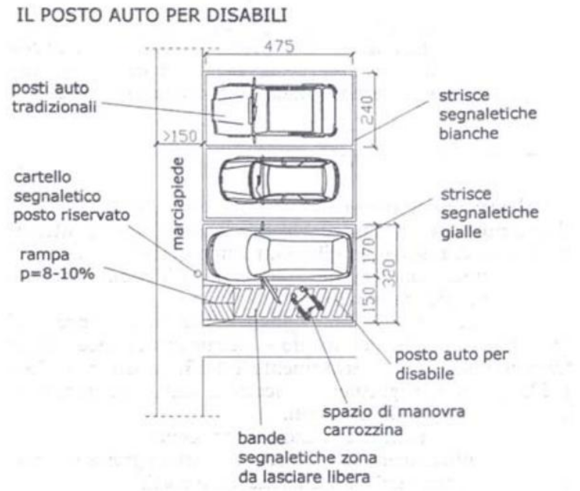
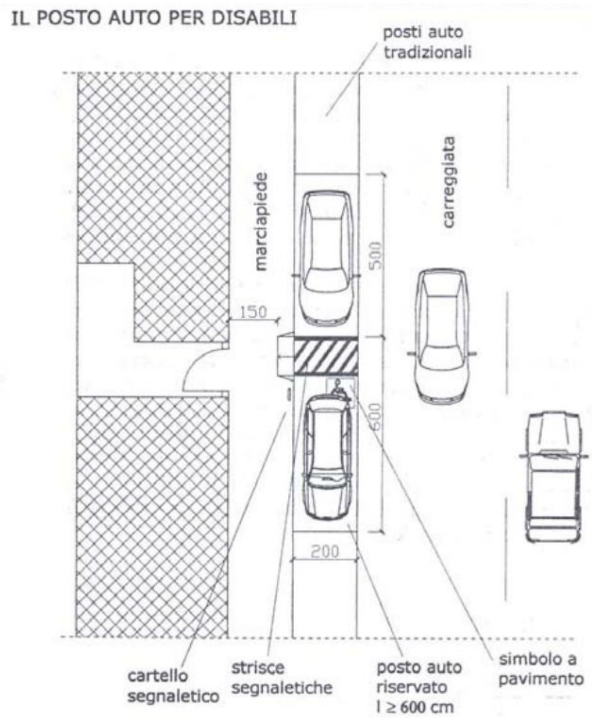


Figure 9. Minimum dimensions of a parking space for users with mobility difficulties



Parking space for users with mobility difficulties in parking spaces parallel to the road Figure 10. in the presence

3.3 Underground and above-ground multi-storey garages

The underground or above-ground garage, as we have already seen, consists of a series of parking levels placed one above the other, horizontal or inclined, connected to each other by ramps of various types (straight or helical) or by mechanical automatic systems that move the cars (multi-storey car park).

Before discussing parking garages, it's important to remember that signs should be posted at the entrance to any parking facility (underground or elevated) indicating the maximum height of vehicles allowed. If space is available, it's recommended that vehicles accessing the parking lot pass under a portal in front of the parking lot itself, with lightweight swinging panels suspended to simulate the building's floor height (minus any lowered ceilings). This way, any taller vehicles are warned of the potential risk of hitting the ceiling, thus avoiding unlikely damage and accidents (Fig. 11).

more Figure 11. Technical device placed before the garage, to avoid damage to tall vehicles

Within a parking deck, the arrangement of vertical structures, pillars or reinforced concrete partitions must be designed to ensure the minimum spaces for lanes and parking spaces to allow for the necessary maneuvers (Fig. 12).

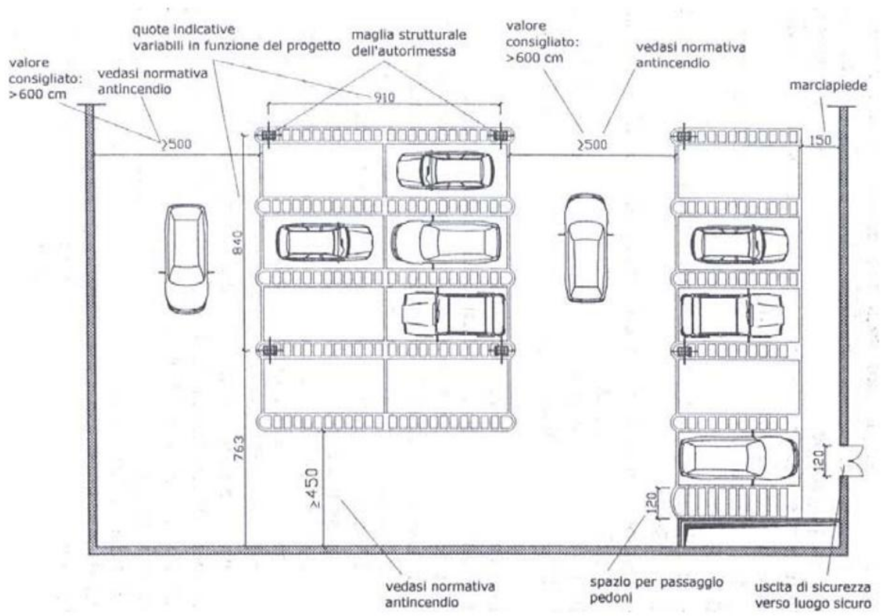


Figure 12. Indicative example of a structural mesh And driveways inside a garage

The parameters that come into play in organizing the internal layout of the garage are therefore: the width of the lane, the length and the inclination of the stalls. Starting from the assumption that if the stalls are positioned at an angle to the lane, it is good practice to have a one-way lane, and that if the stalls are perpendicular to the lane, the minimum size of the lane significantly increases, we can summarize the following: • stalls inclined between 45° and 60° require a lane between 3.50 and 4.20 m;

- stalls inclined between 70° and 80° require a lane between 4.70 and 5.30 m;
- parking spaces perpendicular to the lane require a 7 m lane if two-way march and 6 m if one-way.

In all cases it can be considered that the stall measures only between 4.5 and 5.0 m in length and 2.3 and 2.5 m in width.

Ramps connecting different parking levels can be single, double, straight, continuous, or discontinuous, internal or external, and one-way or two-way. The Ministerial Decree of February 1, 1986, establishes certain characteristics of ramps, such as maximum gradient and width: the maximum gradient is set at 20%, and the maximum width is 3 m for one-way traffic and 4.5 m for two-way traffic. For garages with a capacity of between 15 and 40 parking spaces, a 3 m wide two-way ramp is permitted, provided that the direction of travel is alternate and regulated by traffic lights. Ramps must have a slightly variable slope at the points where they connect with horizontal surfaces, to avoid creating an excessively sharp angle that could cause contact with the underside of vehicles; these connections are typically made along circular arcs with a radius of 30 meters. If the slope of the ramp is greater than 10% (a slope of 15% is generally recommended) it is necessary that in the terminal sections, i.e. in correspondence with the horizontal surfaces, the slope is halved for a horizontal development of approximately 4 m.

The two main types of ramps, helical and straight, have different characteristics. In particular, it can be noted that the type that best meets the requirements of the legislation is undoubtedly the straight one, since, for the same height difference, it takes up significantly less space and can accommodate a gradient between 15 and 20%. While the helical one, to comply with the limits set by the aforementioned Ministerial Decree of 1 February 1986, must guarantee a minimum travel radius of 7 m for one-way traffic and 8.25 m for two-way traffic; therefore, the design reduces the gradient by between 10 and 13%.

A fundamental aspect in choosing the type of garage to be built is determined by whether one-way or two-way ramps are planned, not only for reasons of size (one-way ramps take up more total space because there are at least two, while two-way ramps require a single ramp, which is larger but still unique) but above all for the purpose of separating traffic looking for a parking space from traffic entering/exiting the car park.

Ramps to One Way: They allow for the ascent and descent routes and circulation between floors to be completely independent from the search for a parking space on each floor, thus eliminating traffic conflicts near floor entrances and exits.

Ramps to double meaning: they undoubtedly take up less space than one-way streets but require large areas near entrances and exits that are specifically designed to separate vertical and horizontal traffic.

Among helical ramps, we can distinguish between continuous ramps (i.e. those that go beyond the inter-floor level by completing a complete circumference) and discontinuous ramps (i.e. those that go beyond the inter-floor level by means of a portion of the circumference).

Among straight ramps, we can distinguish: continuous ramps (i.e. those that cross an entire inter-floor space) and straight ramps that cross staggered floors (i.e. the length of the ramp is half that of the continuous ramp since the difference in height to be overcome is not an inter-floor space but half an inter-floor space).

The following images show some examples of parking and garage projects (Fig. 13, 14 and 15).

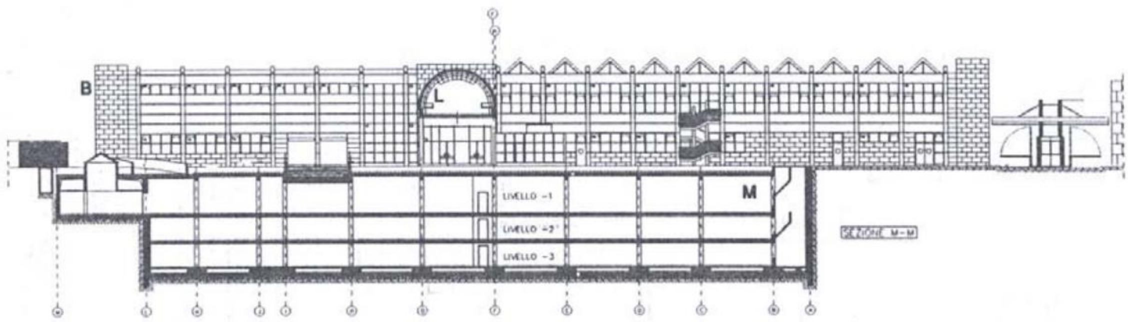


Figure 13. Longitudinal section of the underground garage to service of the Banca Popolare di Milan

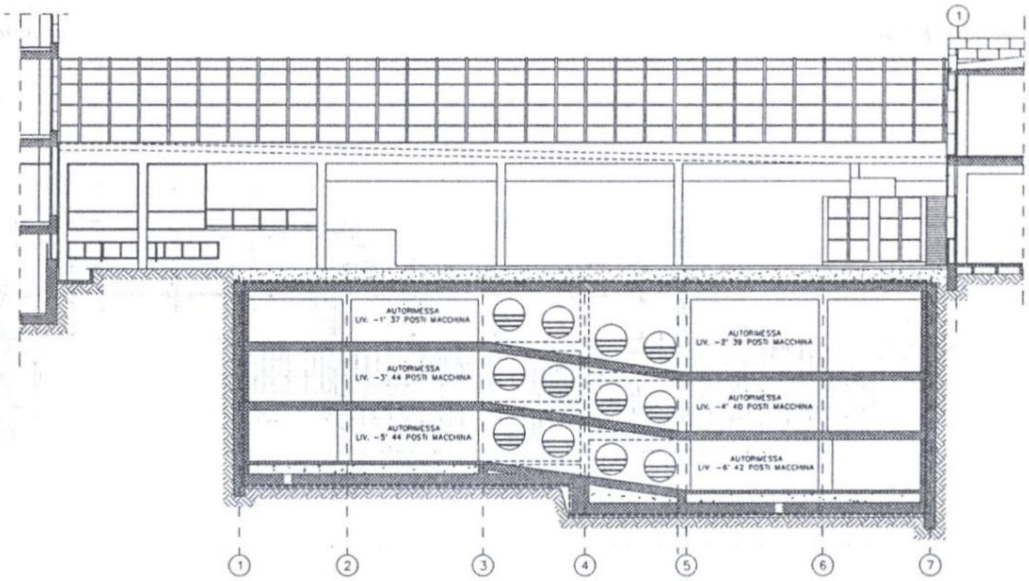


Figure 14. Underground garage project Banca Popolare di Milano service. Cross-section of the six underground levels connected by internal ramps. to double meaning

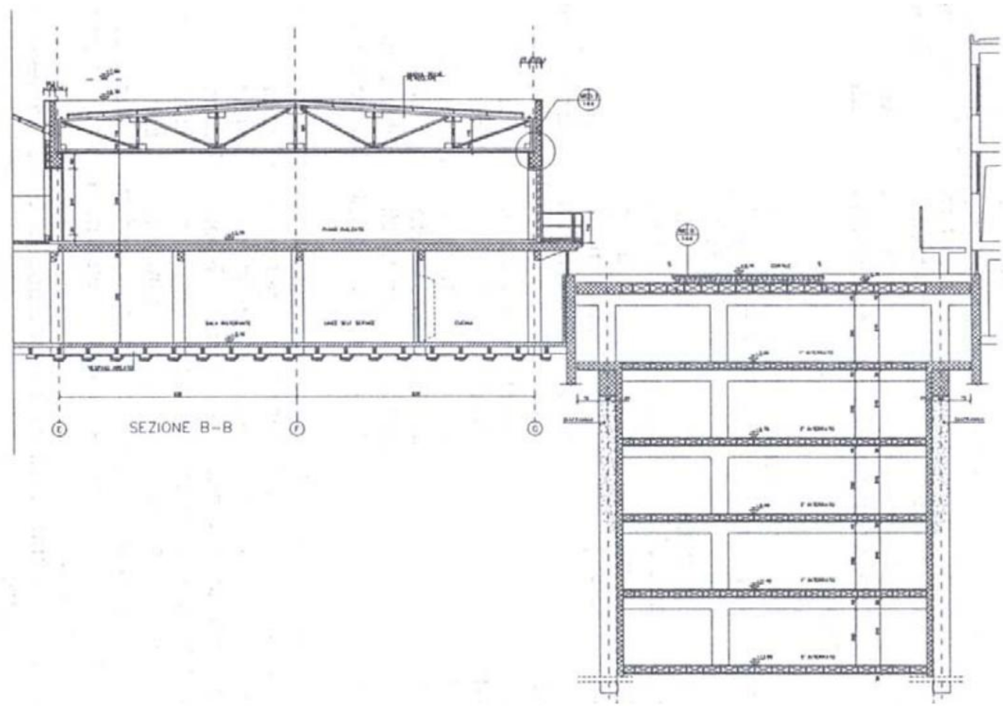


Figure 15. Underground garage project of Serviced by Bayer Italia in Milan. The garage, featuring five underground levels, is nestled between two existing buildings.

A further traffic solution to parking inside garages is the construction of

Ramp-level garages. In this case, the ramp itself, significantly widened, serves as a vertical connection and parking deck. This solution involves greater structural complexity (as a single building must be constructed, but with a "screw" shape), greater architectural complexity, a longer search path for a space, and operational difficulties due to parking on the inclined plane.

of the car.

These types of multi-story parking garages can be used for both underground and above-ground parking. From a functional standpoint, both types of garages provide a higher number of parking spaces than surface-level parking, as these garages allow for multiple levels. Therefore, for the same available floor area, space for ramps is lost, but a significantly greater number of parking spaces are created vertically. From an environmental and architectural perspective, underground parking has a significantly limited environmental impact on the entry and exit areas, while above-ground multi-story parking requires more careful consideration, as it constitutes a truly new building with facades visible to all residents that must be integrated with the rest of the existing buildings.

The underground garages : they are essential in the case of a lack of free surface areas and for reasons of environmental impact; they often allow for the optimisation of the surface arrangement of streets or squares below which the garage is built and in the case of

In parks or areas of environmental value, underground constructions can be constructed that leave the surface conditions virtually unchanged (a blind excavation system typically used for large underground infrastructure projects, such as subways). Therefore, the construction of an underground garage can be defined as a process that does not alter the surface conditions of the site where it is installed, or at least a process of reorganization and restoration of city squares or streets.

The above-ground garages The construction of an above-ground parking garage generally clashes with the urban fabric because it involves infrastructure that disrupts the city's fabric. Often, attention is paid only to the primary function of these buildings, which is undoubtedly to accommodate cars, without regard for their setting, which is of fundamental importance to avoid spoiling the city. Therefore, to avoid the contrast between these buildings and the surrounding city, it is advisable to camouflage them, revisiting the old concept of a carport with a steel and prefabricated reinforced concrete structure that has characterized many such constructions. It is desirable that the facades of these buildings be designed like those of any other commercial building, and all precautions be taken regarding the choice of facade materials, as well as the possible interplay between opaque (closed) and transparent (open) parts. Last but not least, when constructing a parking garage within the urban context, is the use of greenery. As already seen with above-ground parking, this allows the building to be hidden, integrated, and enhanced, blending in with the surrounding environment.

urban fabric.

3.4 Automatic mechanized parking (multi-storey car park)

Automatic mechanized parking consists of a single- or multi-level (above-ground or underground) car container/warehouse equipped with a fully mechanized and computerized vehicle handling and storage system (Fig. 16). The only operation required of the user is to deposit the vehicle in designated areas. The system takes care of parking and storing the vehicle until the request for collection, when it is returned to the designated area and returned to the user for collection.

The car is stored in the following way:

occasional users stop in front of the general entrance barrier and take the card from the machine;

Season ticket holders or parking space owners insert their personal card into the reader, which recognizes them; the user enters the available space, parks the car on a platform, and stops it against the gate;

the barrier closes and the user, to exit, must insert his card into the reader;

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The barrier opens again, allowing exit, and as soon as the sensors indicate that there are no people present at the parking area, the car's transport cycle to the final parking lot begins.

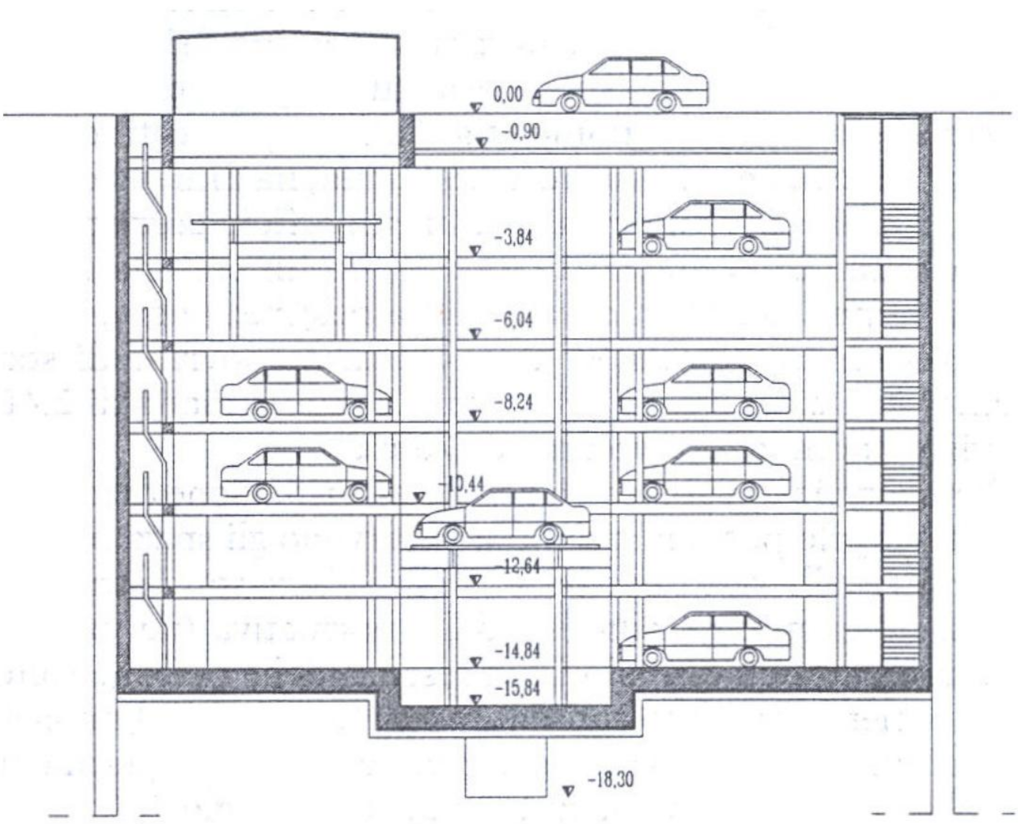


Figure 16. Example of a mechanized, automated parking garage to opposing stalls

The return cycle is similar to the outward one:

Season ticket holders present themselves directly at the exit point and, after inserting their magnetic card into the reader, collect their vehicle, which is automatically parked in the starting position.

Occasional users first pay for parking and then collect their vehicle.

Compared to traditional solutions, multi-storey car parks have the following peculiarities: • greater use of surfaces and volumes, with a consequent increase in the number of realisable parking spaces;

• for the same number of parking spaces, smaller excavations are required (involving smaller surfaces and/or shallower depths); this results in lower excavation costs and less disruption to local traffic and neighborhood life during the works.

In this type of parking, in fact, the volume occupied per parking space varies from 25 m3 (close-row type) to 40 m3 (larger systems); in a traditional building with ramps, the surface area intended for the parking space (there being ramps, the maneuvering and sliding spaces) is approximately 30 m3, which, with floor heights of 2.40 m, correspond to a volume of 70 m3 .

The space savings are due to the reduction in the area reserved for each parking space, as there is no need for opening doors, the reduction in the clear heights under the structure to meet the minimum permitted by law (in mechanized parking lots, since there are no people present, the permitted height between floor and ceiling is 1.80 m), and the elimination of ramps and maneuvering spaces for vehicles moving within the parking lot.

These reductions in space therefore allow, with the same volume, to increase by 40-50% more cars than in traditional parking.

Further advantages resulting from these types of construction are:

- reduction of the complex and expensive service systems of traditional car parks, often making the surface arrangements (ventilation grilles, chimneys, etc.) more aesthetically acceptable;
- complete automation also in management, without the need for personnel presence;
- overall construction and management costs lower than all other types of parking, except for those at ground level;
- safety for the user, for whom finding themselves at night in deserted, albeit protected, premises supervised, constitutes a potential danger;
- safety for the vehicle, which is normally not protected against the possible clumsy manoeuvres of other drivers and is also exposed to the action of potential criminals;
- absence of pollution in parking areas due to motorised movement worn out;
- Modularity and a wide range of solutions capable of responding to the most diverse needs and situations with the most economically viable system. Sometimes, they allow the intervention area to be pre-prepared for the construction of a second module (a twin to the first, currently under construction) in the future, to meet new needs.

Despite the undeniable advantages listed above, other characteristics that influence the use of these types of parking systems must be highlighted:

the presence of complex mechanisms, whose functionality is linked to an electronic control unit; if problems arise (e.g., a power outage), access to the vehicle becomes impossible, resulting in delays; and the average duration of vehicle pick-up and

drop-off cycles, which, although theoretically limited and comparable to those required for an underground car park (from entry to the ramp to the surface), are affected not only by the time required for the various electromechanical and electronic mechanisms, but also by the dexterity of the driver of each vehicle (time lost due to a slow user inevitably affects all subsequent cycles). The return time

Furthermore, the car's capacity depends significantly on the number of cars expected to be moved in the time unit taken into consideration (it is logical to think that during rush hour, such as morning and evening, waiting times increase significantly).

Depending on the type of system used for movement, automated car parks are divided into two main families: • automated car parks with mobile stalls; • automated car parks with fixed stalls.

In the first type of parking, the vehicle moves thanks to a chain drive or a conveyor belt; in practice, the vehicle parks on the same movement device, freeing up the entry point until all available spaces are filled.

All vehicles present in the parking spaces are moved.

In fixed-bay solutions, the vehicle is picked up by a platform that transfers it to the mobile tower; the latter transports the car vertically and horizontally until it reaches the nearest bay. The car is deposited and left there until picked up.

In general, the mobile stall solution is slower than the fixed stall solution and is therefore usable for rather limited parking capacities.

Vertical-horizontal movement can be achieved using two different devices: 1) the crane tower, which combines the two movements simultaneously and reaches the desired location directly (system).

moving tower

This solution is the most suitable when maximum height or depth is permitted, which by law is 7 floors above ground and 6 below ground. Under normal conditions, each tower can serve, through two entry and exit points, 80 to 120 cars distributed across 7 levels;

2) the elevator for vertical movement and the translator for horizontal movement (system). This type of system is advantageous when the available area is sufficiently large and, at the same time, excessive height development is not possible.

horizontal development

This latter system offers significant advantages over a single tower, as it allows for increased speed and, above all, gradual expansion, depending on the specific needs of the system, by adjusting the number and position of the elevators and/or transfer units separately. By varying the number of basic elements, it is possible to create parking spaces ranging from 200 to 3,000.

Automatic systems must be sized to guarantee a maximum waiting time for the user of no more than 8-10 minutes.

Depending on parking capacity, we can distinguish 2 categories of parking:

- small-medium , with modules with a capacity of between 5 and 20 parking spaces (based on the fixed or mobile stall mechanism, they are generally built in courtyards, basements and gardens in the historic center, where space is generally lacking and expensive and where there are often environmental, archaeological and parking access constraints);

- medium-large , with modules with a capacity of more than 40 ÷ 50 parking spaces (based on systems fixed stall).

Medium-to-small parking systems include: a) horizontal, closed-row system (Fig. 17): this allows for extremely low cubic meters /parking space ratios, even for small installations. It consists of two rows of platforms, beneath which is a system of rollers anchored to the ground that move them along a rectangular path. The modules typically accommodate 5 to 17 cars.

The module can be repeated by placing others side by side or by superimposing them on multiple floors (in this case a lift is needed to move the car between the different floors);

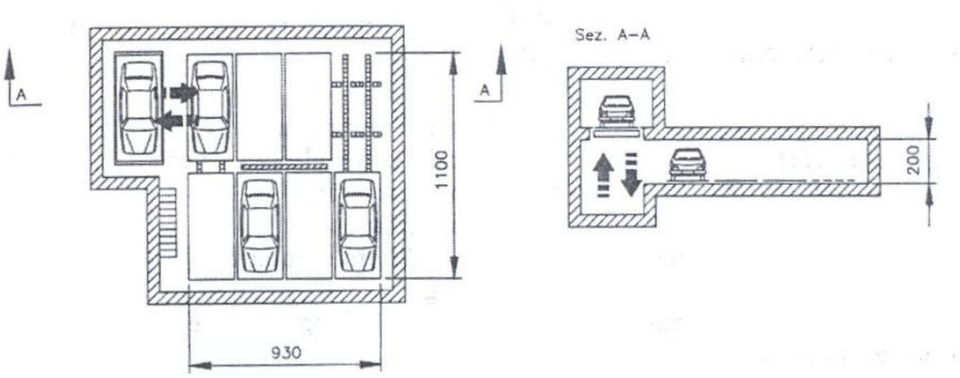


Figure 17. Example of automated parking to closed ranks

b) Horizontal carousel system (Fig. 18): it features a continuous circular motion that makes both releasing and picking up the vehicle in the parking area simple and quick. The platforms are attached to a rail conveyor which, driven by an electric motor, moves them continuously, rather than alternating as in the closed-row system. This system is structured like a ring and the modules can accommodate from 5 to 40 parking spaces;

c) Stacked-lane system: This system consists of two or more stacked rows of platforms, each with a horizontal handling system positioned underneath, and elevators at the ends of the rows. Through a series of alternating movements (horizontal and vertical) of the platforms, the requested vehicle is brought to the exit position corresponding to one of the two elevators in the system. While it allows for up to four levels, this system requires more time than the previously described ones and is therefore not suitable for parking lots with more than two levels (approximately 24 cars);

d) vertical system with two opposing stalls: it is characterised by a series of platforms placed vertically one above the other and arranged, laterally to an elevator, in

Dedicated parking spaces. The vehicle is deposited (or retrieved) on the lift; the lift, moving to the various depth levels, places or retrieves the vehicles to/from their parking spaces. Parking capacity is two spaces per level, and therefore the total number of parking spaces (generally up to 18) is limited by the number of underground and/or above-ground levels that can be created.

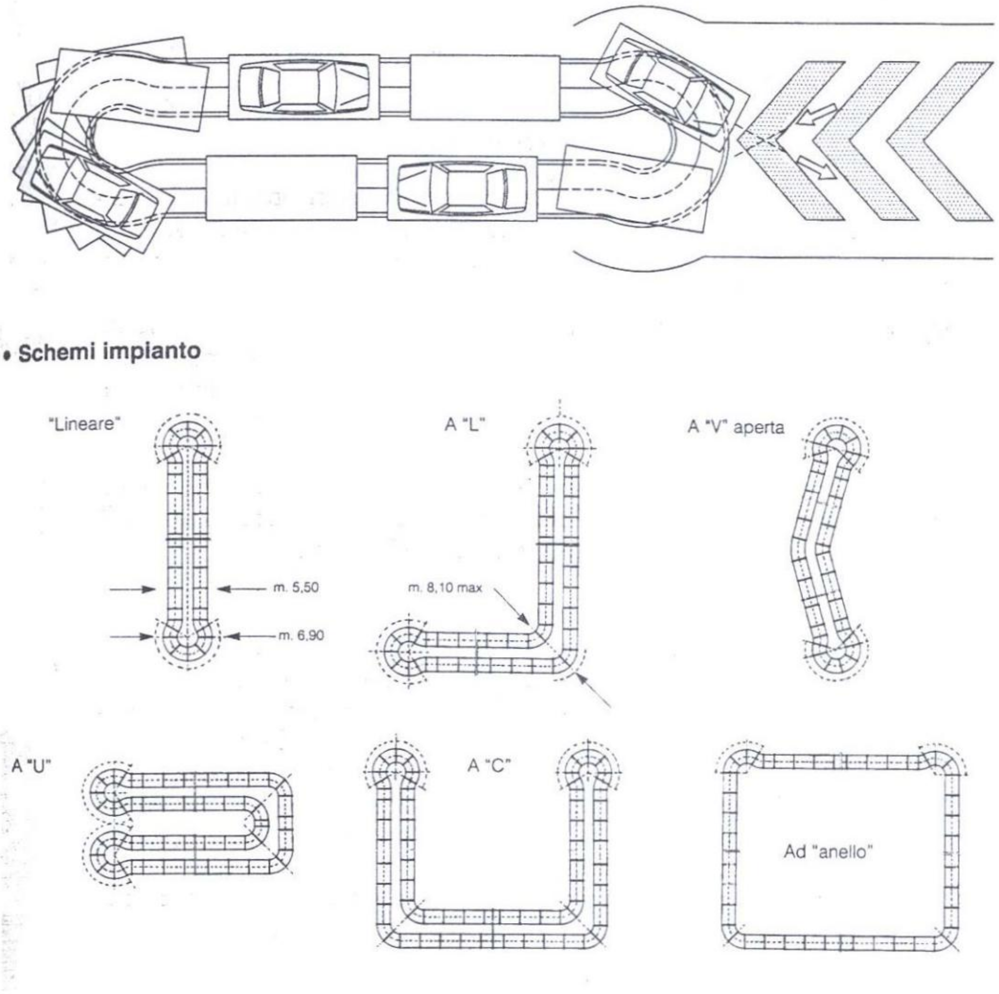


Figure 18. Example of automated parking to carousel

The most common medium-to-large parking structures can be grouped into the following four
categories: a) Vertical system with multiple, opposing stalls: this is an intermediate solution between the two-stall system and the stacker crane system, for structures with 40 to 80 spaces per module. This type of system is suitable for situations where the longitudinal development of the parking structure is limited and therefore the number of parking spaces per level does not exceed 8/10; the solution can be significantly extended vertically, allowing for a partially underground and partially above-ground construction. The system is operated by a lifting table, on which the vehicle handling device travels.

b) Vertical stacker crane system: it can accommodate from 40 to several hundred cars, depending on the specific type of user. This solution is particularly suitable for developments of at least three floors, with an optimal module of 70-80 parking spaces for each stacker crane. Multiple stacker cranes can be installed side by side, thus significantly increasing the parking flexibility (with less disruption, for example, during maintenance). The machine performs both vertical and horizontal movements simultaneously, moving on tracks located in the central space that divides the parking lot in half, thus achieving a diagonal movement that is the shortest possible distance to reach the parking car;

c) Vertical system with fixed lift and transfer trolleys (Fig. 19): it can accommodate from 50 to several hundred cars, depending on the specific type of user. Movement occurs through combined and independent movements (unlike the stacker crane system): vertical movements are performed by one or more lifts, while movements along the central aisle are carried out by transfer trolleys, present on each floor, which are also responsible for the horizontal movement of the platforms or, directly, of the cars;

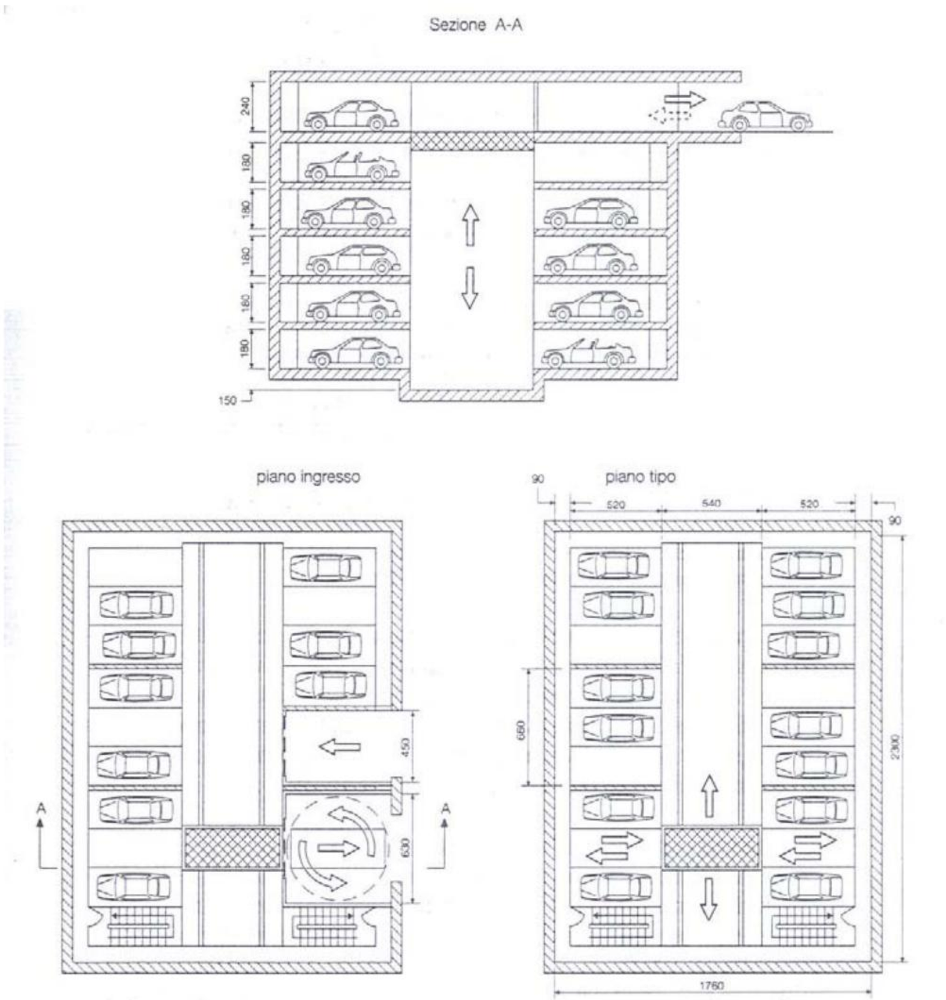


Figure 19. Example of automated parking fixed lift with sideshift trolleys

d) vertical rotating elevator system (Fig. 20): the movement of the cars is carried out by the elevator which, in addition to being equipped with vertical movement control, allows the rotation of the car up to 360° and the subsequent radial movement

For storage/pickup in the parking bay. It requires a minimum diameter of approximately 20 meters to accommodate 12 vehicles per level. The optimal module extends over 5 or 6 levels, and modularity can be achieved by repeating these blocks, i.e., creating multiple parking spaces.

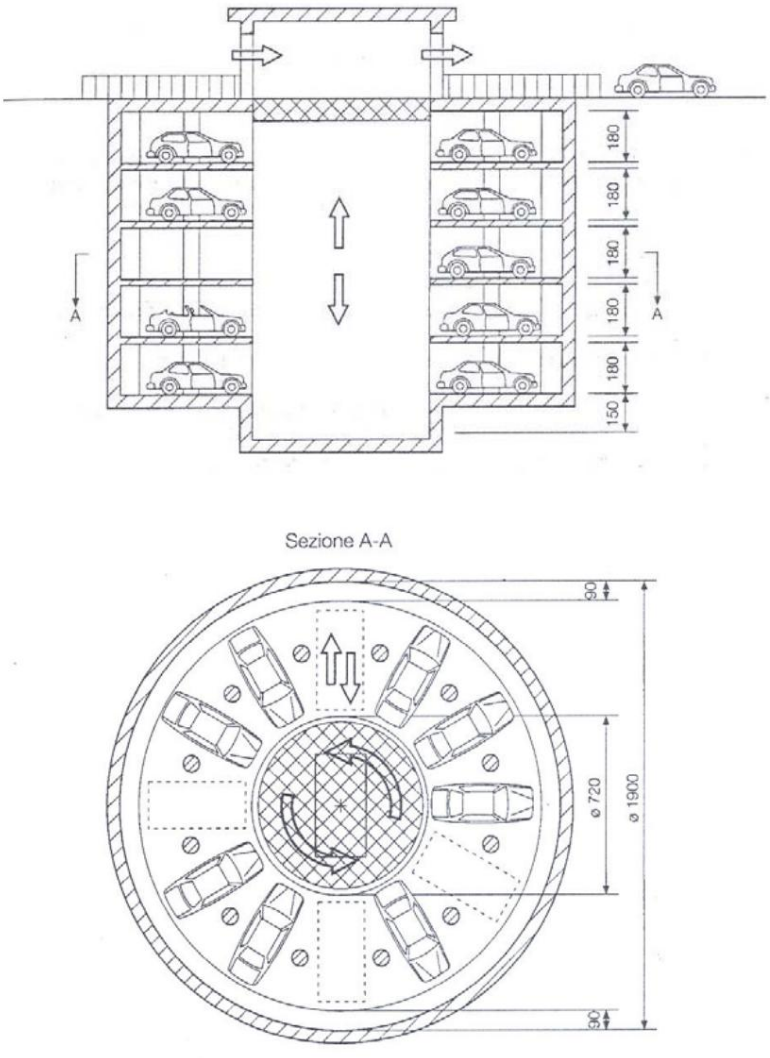


Figure 20. Example of automated vertical parking to rotating elevator

4. TECHNOLOGICAL SYSTEMS

Within car parks, technological systems play a primary role as they ensure the proper functioning of the system and, at the same time, provide the right level of security and reliability.

The technical system elements that interact with the building project and which the designer must take into account during the study phase are the following:

• natural ventilation system;

• mechanical ventilation system; • liquid
evacuation system with settling and sludge separation tanks,
oils and petrol;

• electrical system; •
bathroom water and drainage system; •
lighting system with emergency lights; • fire-fighting
system (sprinklers on all floors); • heating system
(optional); • television systems for monitoring
the entrance and exit points and the spaces
different floors;

• generator for emergency power supply of machinery (for automated car parks); • gas detection
system (optional); • car
movement system, complete with command,
control and management system (for automated car parks).

Beyond the individual aspects related to the specific problems of each individual system, it is important to remember that the system as a whole must be built in compliance with safety criteria that ensure user protection. To this end, reference must be made to Law No. 46 of March 5, 1990, entitled "Regulations for the Safety of Systems," which represents the primary regulatory framework for the design and construction of systems.

In this regard, it should be noted that any system or duct that passes through the REI wall dividing two compartments must be equipped with fire dampers and/or be sealed on the outside with a thermo-expansive product, in order to ensure continuity of REI performance in the event of a fire (sealing with simple roughcast mortar is not permitted).

4.1 Natural ventilation system and mechanical ventilation system The elimination of gases produced by moving vehicles and the air exchange in the garage take place through the integration of two technological systems: natural ventilation (created with special elements without moving parts), and forced ventilation (created using air ducts).

Regarding natural ventilation, the biggest problems arise in underground parking lots, where the effects of wind are virtually nonexistent. In these cases, it is therefore necessary to exploit other natural phenomena that require little space and virtually no maintenance.

The fundamental physical principle used to spread smoke, and therefore hot air, within underground parking lots is the so-called chimney effect, linked to the temperature difference between two spaces at different heights. In practice, a vertical duct (chimney) must be built to connect the parking lot with the outside environment. Within this duct, the air must find a "preferential path" through which it can "migrate" to the outside.

This design solution is appropriate for a single room requiring ventilation. If, as often happens, ventilation affects multiple floors of the basement, measures must be implemented to eliminate the risk of stale air from the lower floors re-entering the upper floors, thereby eliminating and even worsening ventilation there.
last ones.

A technique that allows you to use a single cavity and at the same time ventilate multiple underground floors is the so-called “shunt” type chimney (Fig. 21).

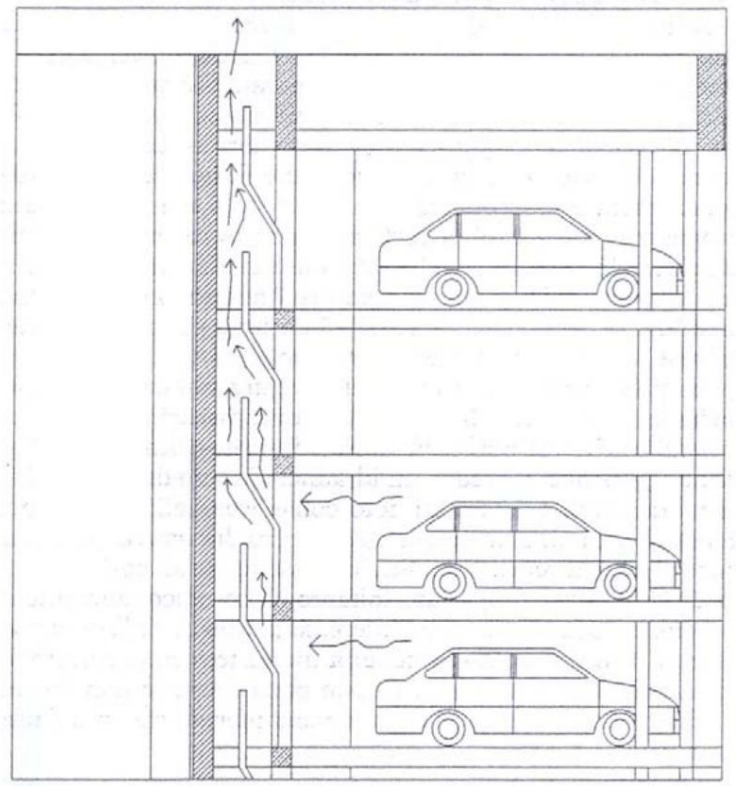


Figure 21. Operating diagram of a “shunt” channel for natural ventilation of the parking lot

With this solution, a baffle protrudes from each floor at the openings, directing ventilation upward for a couple of meters. The air from each floor, naturally expelled, enters the main cavity at a certain speed. Air rising toward the upper floors is unlikely to re-enter them, as it would essentially have to reverse direction, and would be impeded in this process by the shunt from the next floor.

Please note that, due to the type of shunt system configuration, the width of the cavity must be double the minimum width required for the openings on the different floors, as both an inlet channel and a common exit path are required.

On the surface, several alternative architectural solutions to the traditional grate can allow airflow to flow away without allowing rainwater to enter the parking lot (Fig. 22 and Fig. 23).

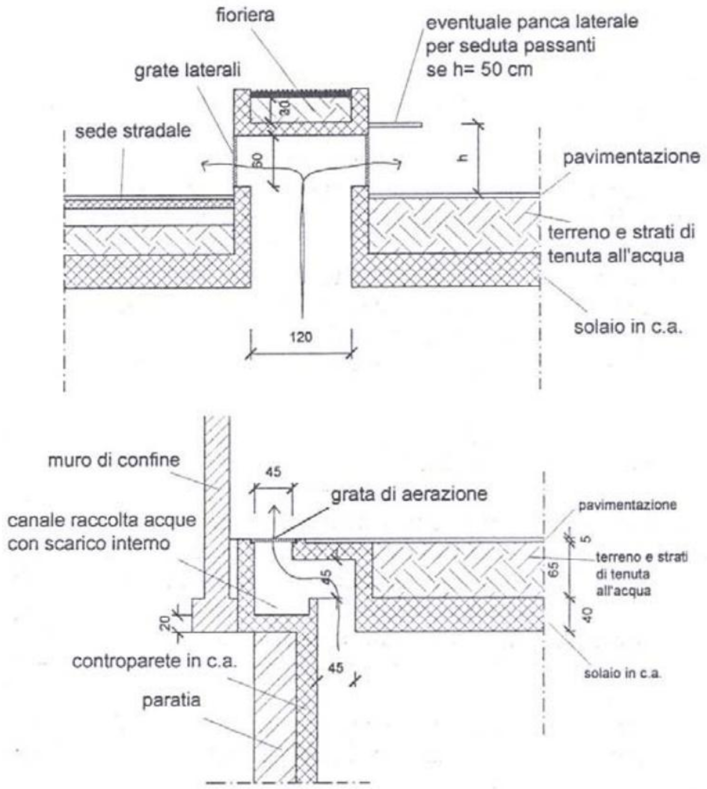
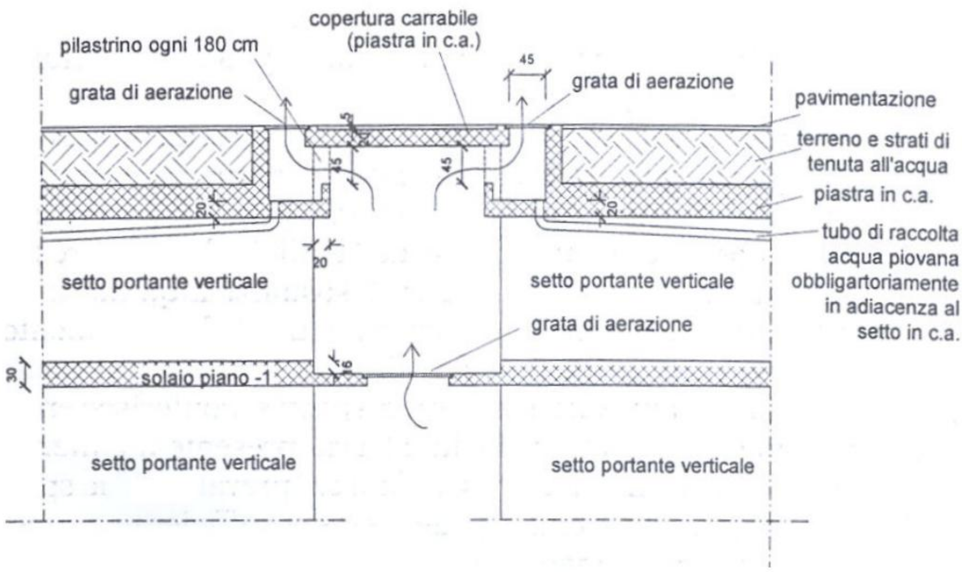


Figure 22. Design alternatives for parking lot ventilation grates



Ventilation figure Rainwater preventing system entry into parking spaces 23.

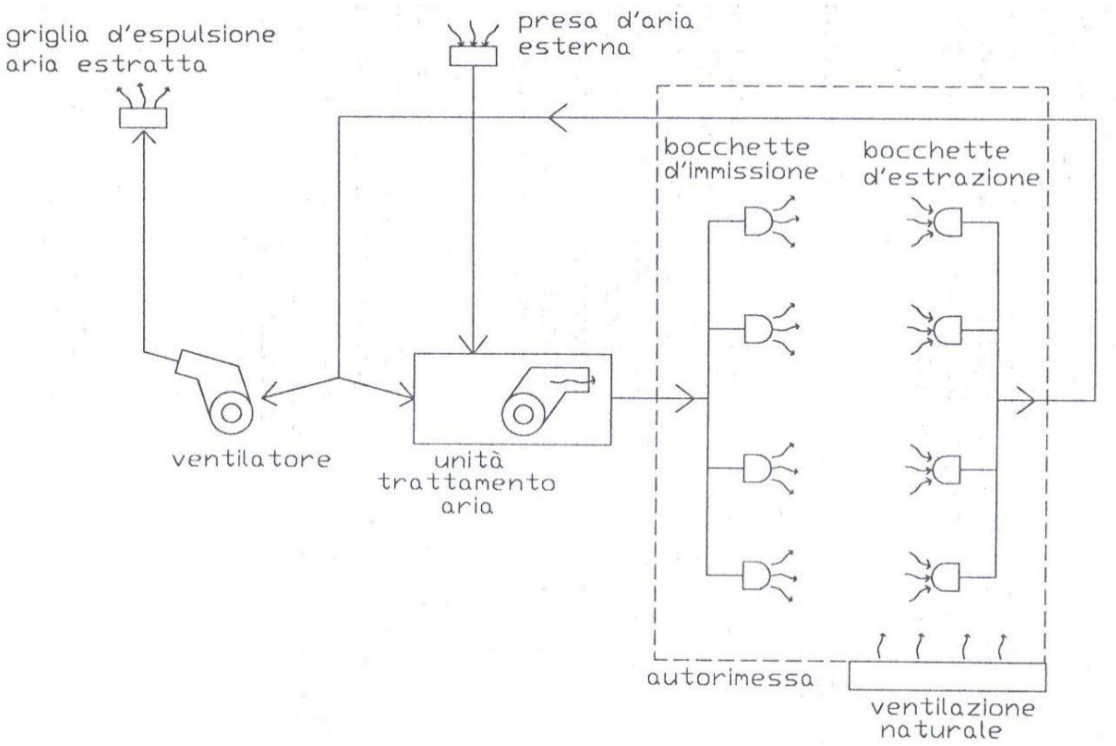


Figure 24. Diagram of the different constituent parts forced ventilation of the garage system

Mechanical ventilation complements the mandatory natural ventilation system. It generally consists of the following parts (Fig. 24):

An external air intake: the air is drawn from an external area of the parking lot, high up and away from any other sources of pollution. Before being released into the building's distribution duct, it must be filtered, that is, cleaned of any dust and pollutants.

A control and command unit: this is the main organ of the circuit, through which, via specially designed fans, energy for movement and therefore speed is given to the air inside the ducts.

Main and secondary delivery ducts; they can be either horizontal or vertical. Generally made of galvanized sheet metal, their size depends on the amount of air they must transport and, for the same amount of air, the velocity of the fluid inside them. For parking lots, the cross-section of these ducts is generally rectangular, as the pressures are not high. The air velocity inside them typically varies from 3 to 12 m/s, depending on the size of the duct. The ducts are fixed directly to the underside of the floors using steel collars, spaced several meters apart, and then secured to the upper support with bolts. If the system does not have a heating function (as is often the case with parking lots), thermal insulation is not necessary.

The air outlet vents: they are used to distribute the air in the widest possible area; they can be placed on the ceiling or on the wall and are generally square or rectangular in shape.

The air extraction circuit (not always present, but mandatory for garages with more than 500 vehicles) has similar characteristics to the supply circuit; it must have intake vents diametrically opposite to the air intake vents, so as to prevent clean air from being drawn in without first integrating the air from the floor.

The expulsion grille: through ducts, the stale air is expelled and introduced in the external environment.

4.2 Electrical system and lighting system The electrical system of a garage must be able to provide an electrical service and at the same time prevent the passage of current to users, protecting from burns or fires due to electric arcs or high temperatures, and avoiding damages connected to disconnections.
electric.

The fundamental elements that make up the electrical system of the car park are essentially five: • the control unit, made up of
electrical control panels, protection devices (circuit breakers, differential switches) and the connection to the external network;
• the earthing system, i.e. the system for protection against accidental contact; • the conduits for transporting the electric current to the various user systems and the lighting fixtures; • the
lighting fixtures; • the emergency
lighting system (independent from the main one).

Electrical panels must be positioned in places safe from possible tampering, and must not be without protection and earthing.

The differential switches must be positioned within the control system. These are nothing more than magnetothermal devices capable of protecting the system from any overcurrents and short circuits.

The lighting in the rooms used as garages must not be less than 20 lux, a value which regulations define as the minimum lighting allowed for passageways, corridors, and stairways. Near areas where parking attendants work, this lighting must obviously be increased with higher-output lighting fixtures.

One final important aspect concerns the emergency lighting system, that is, the system that guarantees a minimum level of lighting even when the main system, due to shutdowns or malfunctions, is no longer active.

The regulations require that garages with a capacity of more than 300 vehicles and all multi-storey car parks (therefore automated car parks) must be equipped with safety lighting systems powered by energy sources independent from the mains supply.
normal lighting.

The lighting intensity must be sufficient to allow for the evacuation of people and in any case cannot be less than 5 lux. This system can be powered by backup batteries.

4.3 Liquid drainage system The garage,
although being a closed and waterproofed underground construction, must be equipped with a water collection system and, consequently, a connection to the sewer system.

Water can in fact penetrate the parking lot together with the vehicles (especially in case of snowfall), or from the grates for natural ventilation.
Larger garages and multi-storey car parks also require an automatic fire extinguishing system, which in most cases uses water. It's clear that water cannot be left on the attic floors or "forgotten" on the basement level.

In the case of underground car parks, where there is groundwater, any potential infiltration from the walls is another reason why this system is mandatory.
Even for surface parking lots, it is important to provide a rainwater collection system: in this case, it is a good idea to create a system of slopes for the parking area and a series of collection tanks as illustrated below.
The fluid evacuation system (Fig. 25), can be identified by the following four
subsystems:

- Collection and conveyance pipes: on each floor, the liquids must be conveyed to specific points via slight slopes and from there channelled towards the collection tanks.
- Collection and sedimentation tanks: For obvious reasons, water is not discharged from the parking lot continuously, but intermittently. The collected water is stored in special tanks until the liquid level exceeds a predetermined level. To slow the flow of incoming liquid, a movable barrier (sediment gate) can be installed in front of the tank entrance.

- Separators for light liquids, oil, and grease: when designing garages (but also for surface parking lots and multi-storey car parks), it is necessary to include, upstream of the sewer collector, a series of devices that eliminate the possibility of wastewater contamination, preventing oils or greases from ending up in the sewer system. These devices, placed in sequence immediately after the collection tank, are in turn tanks with multiple baffles.

which, by means of filters, allow the separation of the oil constituting the first floating layer that overflows from the collection tank. The layer of oil and grease must be periodically removed. •

Lifting pumps: given the great depth to which a parking lot can reach (20 meters underground), the sewer pipes are often at a higher level than the collection tank. It is therefore clear that it is not possible to evacuate the liquids using gravity alone, but it is necessary to provide an adequate hydraulic load to overcome this difference in height. The liquids collected from the collection tank are thus periodically pumped into the sewer system; the control is generally automatic and obtained via a suitably calibrated float device: when the water exceeds a certain level, the pump is activated and remains active until the latter level drops below a pre-established threshold.

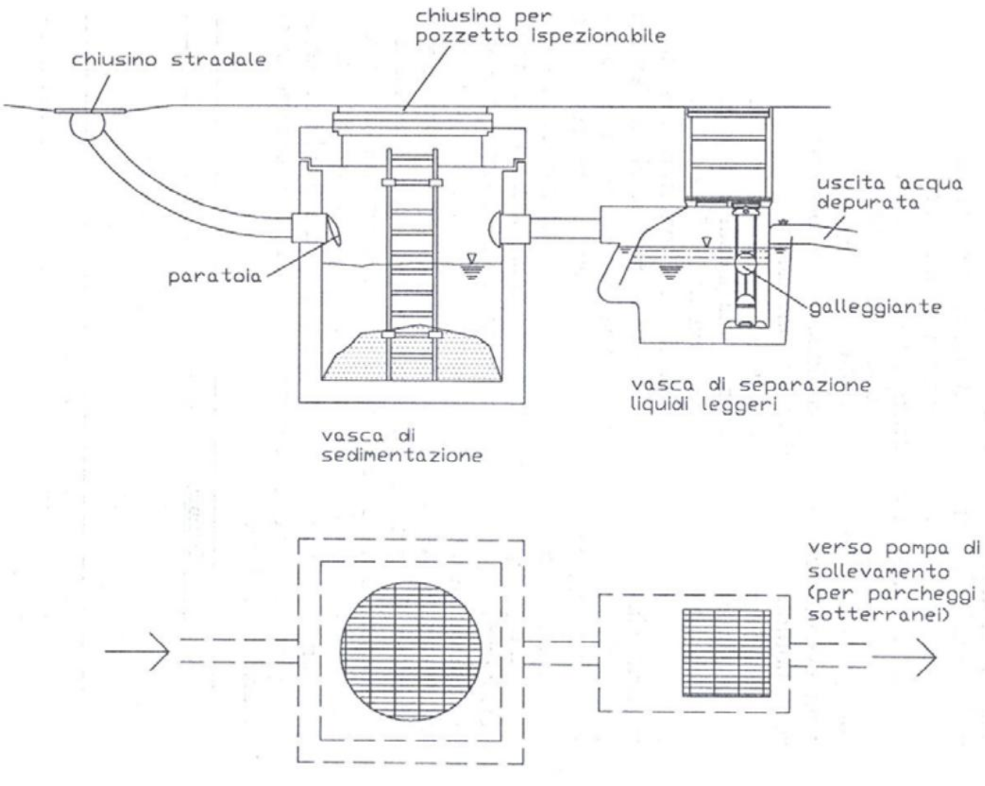


Figure 25. of a Diagram evacuation system liquid

4.4 Fixed automatic fire extinguishing system Inside multi-storey car parks with a parking capacity of more than 9 vehicles, in garages with more than 2 underground floors and/or more than 4 floors above ground (if closed) and/or more than 5 floors above ground (if open), as expressed in the safety regulation for the construction and operation of garages and similar (Ministerial Decree 1 February 1986), it is mandatory to "install

a fixed automatic fire extinguishing system of the sprinkler type with water supply or of the open dispenser type for the supply of water/foam".
This system must be activated as soon as the outbreak begins to develop: when this happens, an alarm goes off to warn users of the possible danger.
In general, the following components can be identified in sprinkler systems (Fig. 26):

a water source (mains, gravity tank, automatic pump sucking from a tank or other reservoir, pressure tank); a water
intake pipe (from the source to a control/alarm valve); a distribution network connecting the main valve to the users; a system of sprinkler nozzles.

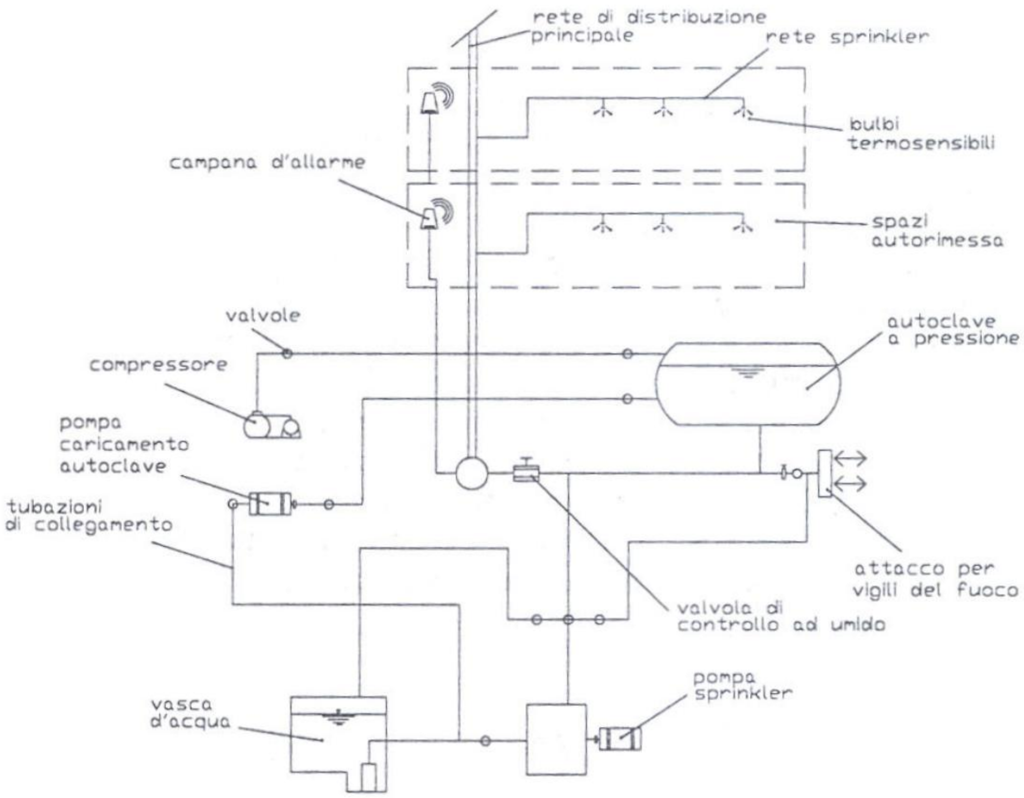


Figure 26. Operating diagram of a generic sprinkler system

It should also be remembered that the same 1986 decree, for fire prevention purposes, requires the additional presence of fire extinguishers and hydrants connected to special pipes independent of those of the sanitary services.

4.5 Car handling system (for automated parking)

In general, mechanical handling typologies fall within two large families: • parking lots with
mobile stalls;

• parking spaces with fixed spaces.

In the first case, the system consists of translating platforms positioned on guides fixed to the reinforced concrete slab. Each guide is equipped with rotating cylinders that allow the stall to slide, reducing friction and therefore energy consumption.

Whenever the parked vehicle is called by the owner, the platforms all move in a closed circle, until the requested vehicle is located in correspondence of the elevator.

In the second case (fixed stall system), two further mechanical typologies can essentially be identified: • the crane tower;

• the elevator with steel beams sliding from top to bottom with platform translating.

The crane tower consists of a lattice system of steel struts and tie rods, moving on rails (Fig. 27). The mechanical control components and the pulley system can be located at the top (the space occupied is approximately 50 cm in height) or at the bottom of the tower (a more expensive solution).

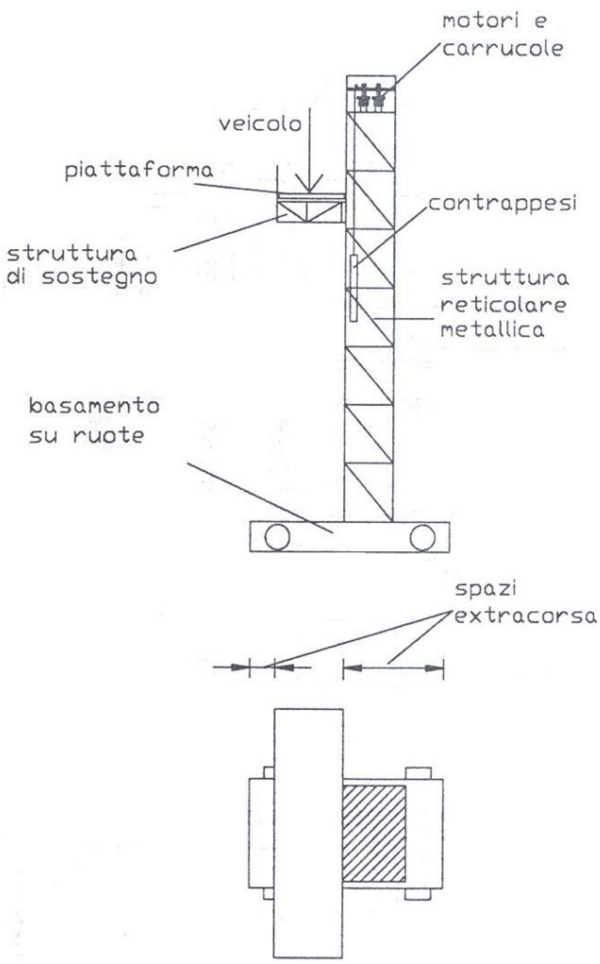


Figure 27. Diagram of a crane tower for the operation of a automated parking

The vertical movement of the elevator's "translaveture" platform is achieved by means of steel cables and the use of counterweights that determine one or more technical spaces to be created inside the side walls or through slots inside the floors.

The vehicle loading and unloading system from the stalls consists of a motorized trolley placed on the tower platform. Once the shifter has positioned the platform in front of the stall, the trolley is positioned underneath the vehicle and, using a suitable mechanical system, lifts it and moves it to the central part of the parking lot.

The second system uses, instead of the tower, steel IPE beams that slide on lateral metal guides (Fig. 28).

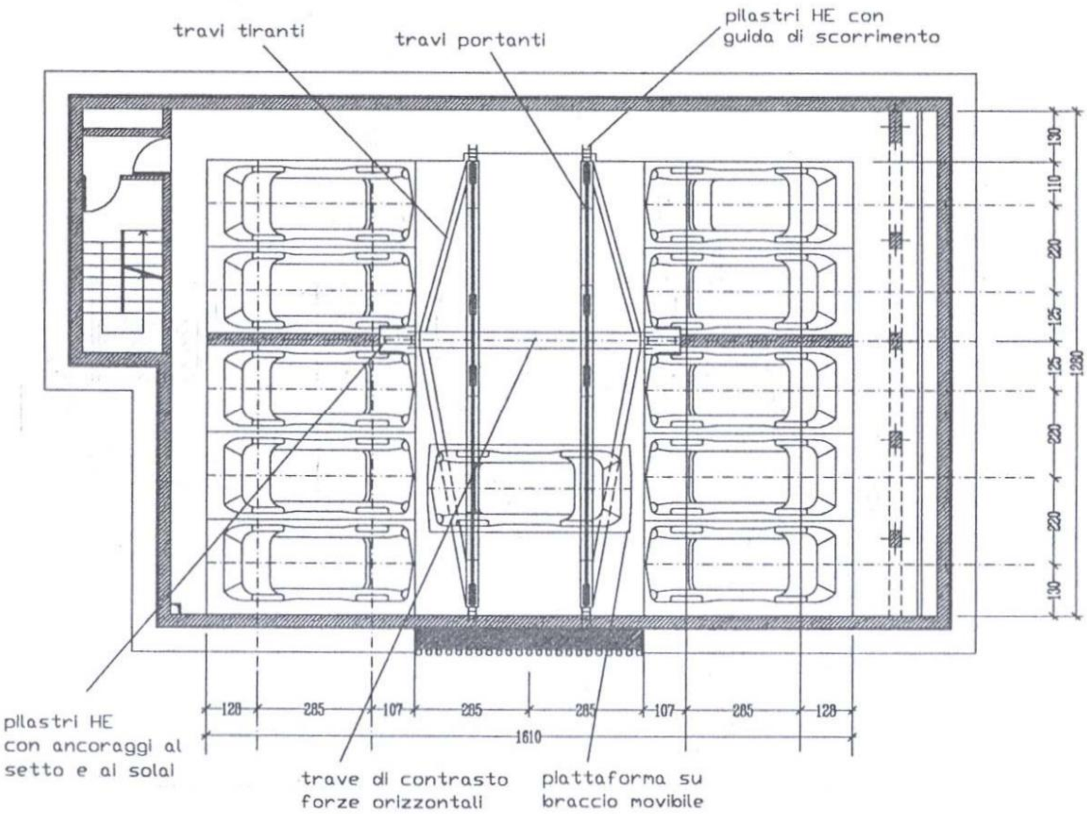


Figure Automated parking with elevator 28. to sliding horizontal beams

These metal guides must be anchored to the reinforced concrete structure. For this reason, it is common to cast steel HE pillars in the concrete at these points, and then install the mechanical system interface on them.

In this device too, the vehicles are picked up via an “extendable arm” that lifts the vehicle from its stall and places it on the lifting beams.

Automated parking garages, which are generally built in narrow spaces, courtyards, or places where a parking space should not be architecturally invasive, can be equipped with a retractable roof. This system allows, from a visual standpoint, the almost total "absence" of the parking space, as only a small area remains outside.

entrance barrier and, around the entrance stall, a surrounding hedge or a low wall with glass windows without a covering.

The electronic magnetic card entry system is located in a turret adjacent to this entrance.

If a user arrives and inserts the appropriate identification card, the roof raises and their vehicle appears on the platform, ready to be collected and used.

5. FIRE SAFETY REGULATIONS

All spaces intended for the storage of motor vehicles, and in particular underground garages or those located inside buildings, were among the first to highlight problems related to fire prevention.

The legislation that currently regulates fire safety in car parks is the Ministerial Decree of 1 February 1986 entitled "Safety regulations for the construction of garages and similar".

This decree does not specifically indicate a general criterion to follow for the design of garages and similar structures, but it highlights characteristics to take into consideration when adopting all fire prevention measures.

For garages with parking capacity for fewer than nine vehicles, there are few mandatory regulations to comply with, and more building concessions are available; for more than nine vehicles, the regulations are more stringent. In particular:

It is not permitted to use rooms located above the sixth basement level or the seventh above ground level as garages.

For insulation purposes, structures separating them from other buildings or other parts of the same building must be at least REI 120. They may be REI 90 if the garage is protected by a fixed automatic fire extinguishing system. Rooms not protected by a fixed automatic fire extinguishing system cannot be directly below the openings of entertainment venues, hotels, schools, hospitals, and retail outlets.

Multi-storey car parks must have separation structures from other activities with a resistance of no less than REI 180, and horizontal and vertical load-bearing structures that are not separation structures. must be non-combustible.

The height of the floors cannot be less than 2.40 m, with a minimum of 2 m under the beam.

For multi-storey car parks, a minimum height of 1.80 m is permitted (Fig. 29).

The specific parking area cannot be less than 20 m2 for unattended garages, 10 m2 for attended garages and multi-storey car parks.

The passages between the different levels of the garage, pedestrian ramps, stairs, elevators, and lifts must be external or enclosed in cages made of non-combustible structures and equipped with self-closing doors of at least REI 120 type.

Figure 29. Minimum inter-floor heights to be respected in a garage project

Maneuvering lanes must allow for the easy movement of vehicles and must be at least 4.5 m wide and 5.0 m wide in the areas in front of garages or parking spaces perpendicular to the lane. Smaller widths (but at least 3.0 m) are permitted, provided that appropriate signage is installed to highlight lane narrowing, complemented by suitable optical systems (e.g., parabolic mirrors) at lane changes.

Accesses must be located on walls facing streets, public or private squares, or open-air spaces. For multi-storey car parks, a space must be provided for receiving vehicles. This space, measuring at least 4.50 x 5.50 m, must have:

the same construction characteristics as the multi-storey car park.

Each compartment must be served by a pair of one-way ramps no less than 3.0 m wide or a single two-way ramp no less than 4.50 m wide. The gradient cannot exceed 20%, and the minimum radius of curvature on the outer edge is 8.25 m for two-way helical ramps and 7.0 m for one-way helical ramps (Figs. 30, 31, 32, and 33). For garages with a capacity of between 15 and 40 cars, a single ramp no less than 3.0 m wide is permitted, provided that a suitable traffic light system is installed to regulate alternating one-way traffic on the ramp.

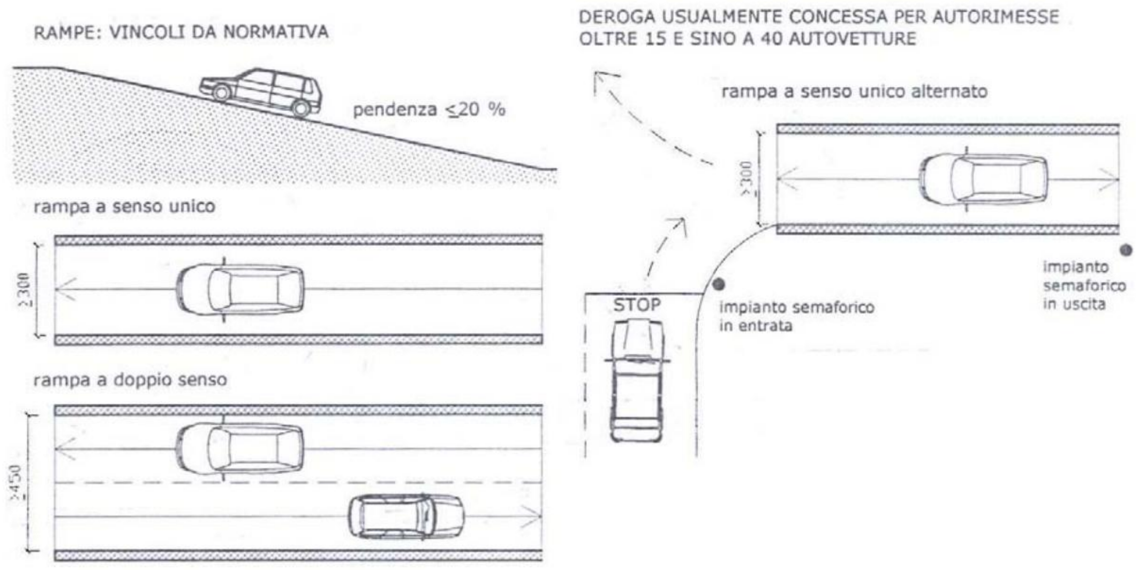


Figure 30. Regulatory requirements for the construction of straight ramps

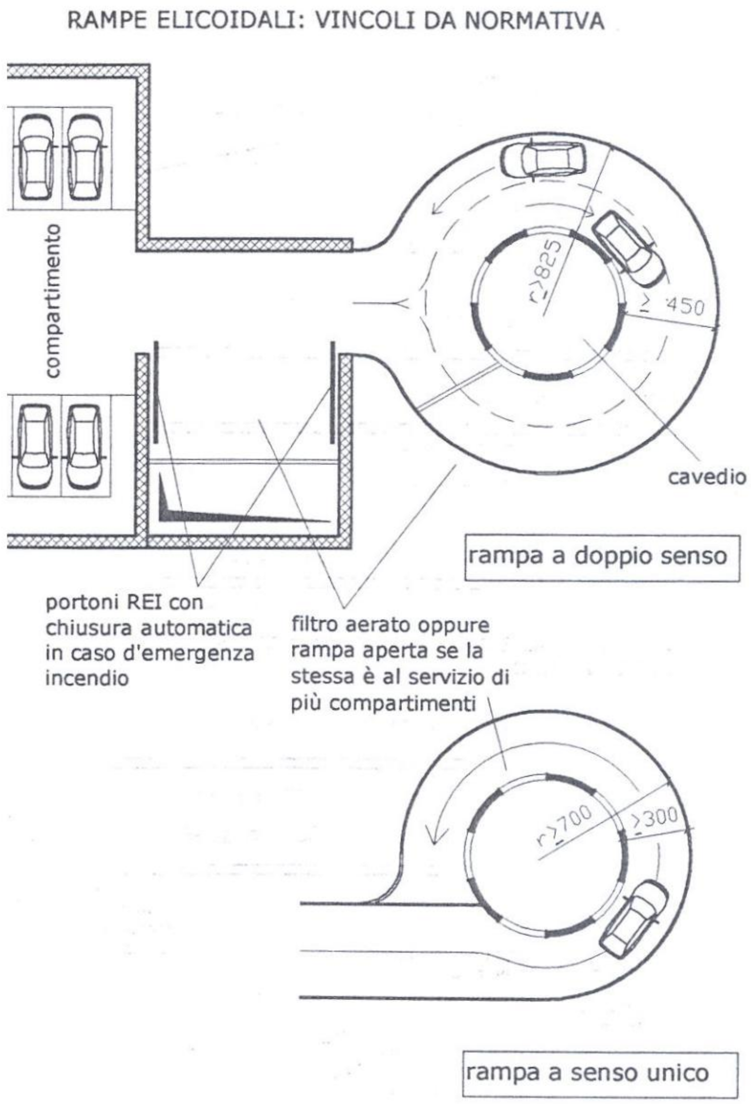


Figure 31. Requirements for the construction of spiral ramps regulationsfor

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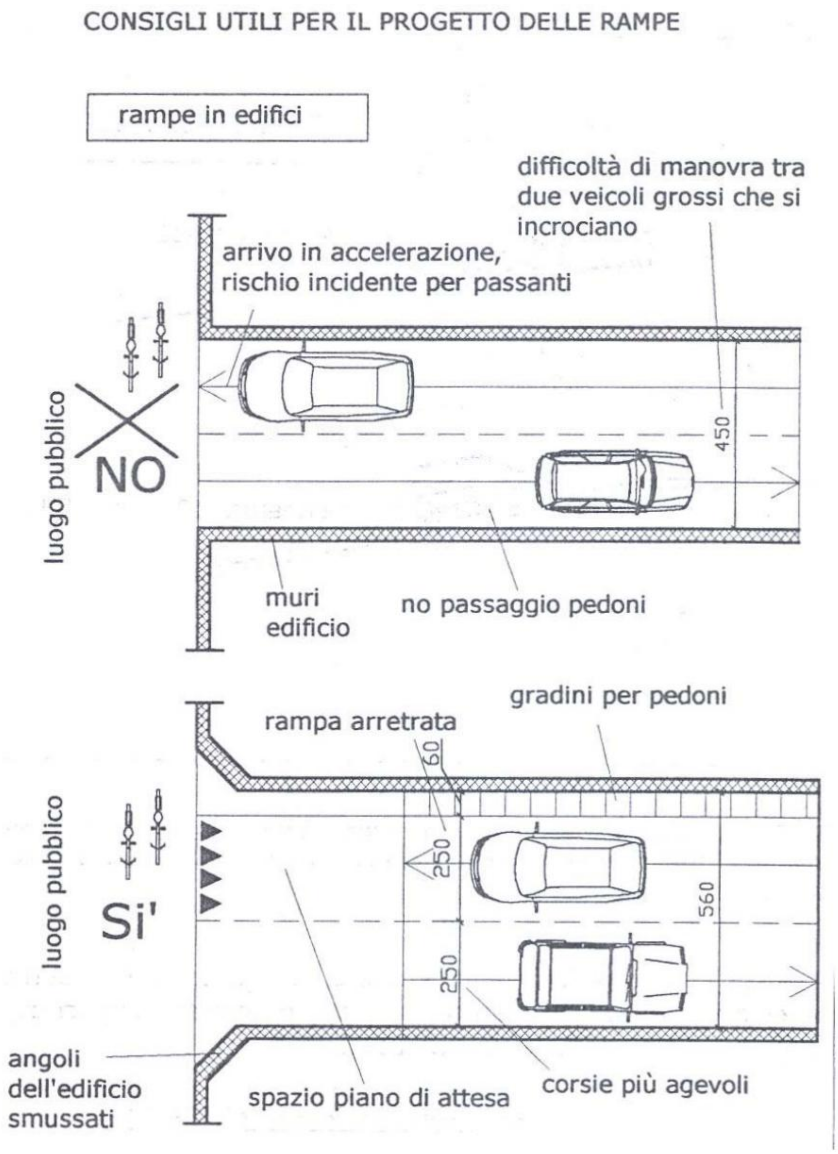

Figure 32. Helpful tips for ramp design

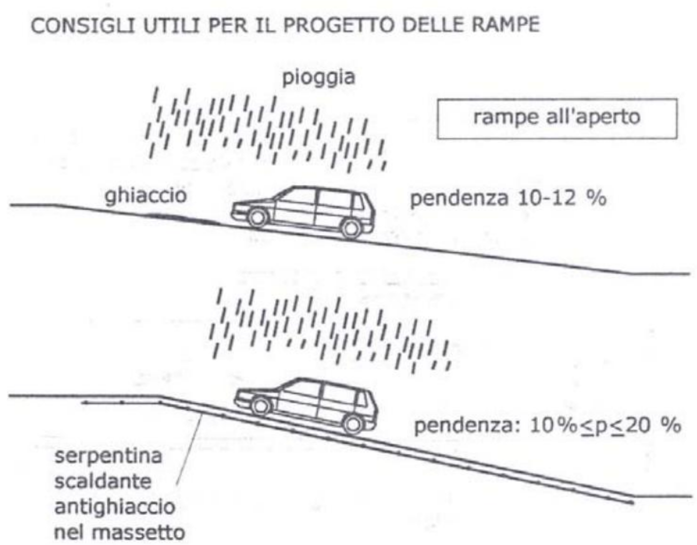

Figure 33. Tips for designing outdoor ramps (subject to adverse weather conditions)

Floors must have a sufficient slope to direct water into collectors and collect it in a device designed to separate flammable liquids from waste water. The flooring must be made of non-slip and waterproof materials.

All garages must be equipped with a natural ventilation system consisting of openings made in the walls and/or ceilings and arranged in such a way as to allow effective exchange of air in the room, as well as the disposal of heat and fumes caused by a possible fire. To ensure adequate ventilation of the rooms, ventilation openings must be distributed as uniformly as possible and no more than 40 m apart.

Natural ventilation openings must have a surface area no less than 1/25 of the compartment's floor area. Where mechanical ventilation is not provided, a portion of the surface area, no less than 0.003 m2 per square meter of floor space, must be completely free of windows and doors.

The ventilation system must be independent for each floor. For underground garages, ventilation can occur through cavities and/or chimneys; if the same cavity is used, to allow independent ventilation for each floor, vertical sectioning or shunt ducting can be used.

The natural ventilation system must be supplemented with a mechanical ventilation system in underground garages with a maximum number of vehicles per floor exceeding the following values: 125 (first floor), 100 (second floor), 75 (third floor), or 50 (above the third floor). Garages with more than 500 spaces require a dual mechanical ventilation system for air intake and exhaust, controlled manually or automatically by means of CO and flammable gas indicators.

Exit routes, whose width is determined by the ratio between maximum occupancy and flow capacity, cannot be less than 1.20 m; if the parking lot has multiple exits, one exit must be 0.60 m wide. Exits must be accessible via routes of less than 40 m (50 m if an automatic fire extinguishing system is present). For underground parking lots, exit routes may end under gratings equipped with devices that can be easily opened from the inside.

The ministerial decree of 1 February 1986 does not explicitly distinguish between different types of vehicles and the motorcycle class is not mentioned, since, in a certain sense, the decree assumes that garages are designed for cars only. Nonetheless, the increasing number of motorcycles and mopeds parked in garages in areas subways has led the General Directorate of the Fire Brigade to express an opinion regarding the parking of these categories of vehicles. Circular No. P713/4108 of 25 July 2000 provides guidelines for designing garages in these cases.

Essentially, for two-wheeled vehicles, a specific parking surface of 2.5 m2 is envisaged in the case of supervised garages and 5.0 m2 in the case of unsupervised garages; therefore, the introduction of an equivalence parameter is considered admissible.
between motor vehicles and motorcycles or mopeds in the ratio of 1 to 4.

As regards lighting, garages must be equipped with safety systems powered by an energy source independent of the normal lighting network. In particular, said safety lighting systems must have the following characteristics: • automatic and immediate activation as soon as the normal lighting fails; • lighting intensity necessary for carrying
out evacuation operations and

in any case not less than 5 lux.

Regarding fire protection and extinguishing equipment and systems, the decree of 1 February 1986 states that: • Multi-storey car parks must
always be protected against fires by a fixed fire-extinguishing system; the same applies to garages below the second underground floor, above the fourth floor above ground (if closed), and above the fifth floor above ground (if open).

• The water supply network must be constructed with galvanized iron pipes or equivalent materials protected against frost and must be independent of the sanitary network. • The system must
be normally supplied by the city water supply. It may also be supplied by a water reserve consisting of a tank equipped with a special pumping system (this becomes necessary when the city water supply is unable to continuously guarantee the required supply).

• The system must always be kept under pressure and equipped with a connection for the Fire Brigade vehicles, to be installed in a clearly visible point and easily accessible to the vehicles themselves.

• Fixed automatic fire extinguishing systems must be of the sprinkler type, with water supply or of the open dispenser type for the delivery of water/foam.

Bibliographic references

ÿ C. Brambilla, G. Cusmano. **Designing and building public and private parking lots.** Maggioli Editore. March 2005.