Via Dolorosa. Photographed at the beginning of the 20th century.
(Library of Congress, from Wikipedia site)

PEOPLE, DONKEYS, WHEELS AND STAIRS

Yael Danieli Lahav

Wheels and stairs can be thought in terms of “a little that holds a lot”. The wheel sets the technological system in motion, the stair stands at the foundation of the tectonic system. There are plenty of wheels, and stairs are not lacking either.
When writing these lines, there are no available technological solutions, simple and affordable for every person, that allow an ordinary person to climb stairs with the help of wheels.

Architect Yael Danieli Lahav. School of Architecture and the Department of Physiotherapy at Ariel University. A senior architect who has specialized in the planning and design of a built environment accessible to people with disabilities. Among other things, she advises to the municipality of Jerusalem on issues related to accessibility policy and making accessibility adjustments in the public space of the Old City.
This article was first published in the on-line journal Architect II on 2011 (the link to the issue in which it was published):

Stairs, by their very nature, are designed for pedestrians – human beings or four-legged. In fact, the body of those who walk on their feet is made in such a way that the entire structure of the limb, and its connection to the torso[1] is by its very nature intended for climbing. Each limb moves individually, while the whole body maintains balance, and the ability to move forward or backward (albeit in a more limited way) even when one limb is standing on a higher or more curved surface than the one on which the other is standing. Our ability to successfully deal with asymmetry situations in the limb position depends on the structure and function of the skeleton, joints, muscles, nervous system and sense of movement (kinesthesia)[2] that each and every one of us has.

For the benefit of the movement with the help of wheels humans pave roads. Even if they are sometimes quite uneven, the quality of the ride depends on the quality of the wheels, and the extent to which they are suitable for dealing with the road conditions.

If grandma had wheels…

Typing on the pair of words wheelchair stairs on Google search engine uploaded 2,540,000 results. A lot of people have been trying for a very long time to be able to climb stairs using personal wheels. So far without impressive results. The existing solutions are too expensive, too cumbersome, not suitable for operating in too wide a range of surface types, have difficulty dealing with chaotic stair walks (non-uniformity of the dimensions of the tread and rise along the walking route), require too high skills and depend on propulsion technology with too low efficiency ... in short - even if such devices can be adapted at home, on the street, or worse, in open-air areas - they are simply not applicable.

In this article I will try to show how complex the matter is for people, who at a given moment, or usually, are unable to climb stairs.

People and donkeys that prefer stairs

With the invention of the stairs, it became possible for the first time to build high-rise buildings and compress a large number of activities on one piece of land. In my opinion, stair architecture strongly expresses the builder's spirit, and I would even go so far as to say that with the discovery of how to use a right angle, stairs are the epitome of architectural thought. Where a staircase is found there was a human being.

In the eastern basin of the Mediterranean, donkeys and mules were the main means of transportation throughout the centuries prior to the 20th century. Since the introduction of motorized vehicles, the use of pack animals has greatly diminished, though not completely disappeared. The body structure of the domestic donkey is relatively small compared to the body structure of other pack animals (the horse, the mule, definitely the camel). The length of the domestic donkey, from the tail to the tip of the nose, reaches about 160 cm, the back width about 70 cm, and its height ranges from 95 to 125 cm.[3] The donkey's head

1 The torso is a name in anatomy for the largest parts of the human body, without considering the limbs and head. The torso includes the parts: chest, back and abdomen. Source: Wikipedia.

2 Kinesthesia, Kinesthesis, the sense that allows the brain to be aware of the position and movement of the muscles in different part of the body. Source: www/informed.co.il/glossary/g_3527.htm

3 Source: http://www.donkeybreedsociety.co.uk/page/AboutDonkeys

and neck are long and heavy relative to its humble body and slender legs. The distance between the axis line of the front legs and the axis line of the hind legs of the average donkey ranges from 90 to 115 cm, a figure that was taken into account when building streets with a slope of 8%-25% (i.e., a ratio of 1:12-1: 4). The donkey lives about 40-60 years (depending on its health and growing conditions), and is able to carry a very large load in relation to its body size. It is a stubborn but extremely intelligent animal, and has a high ability to adapt to difficult terrain conditions. Due to the donkey's body structure, a heavy load shifts its center of gravity too far from the balance point, making it difficult for it to maintain stability on a sloping road. Moderate stairs with a wide tread and a rise of 10-13 cm, solve the problem, because they allow the donkey to have a relatively balanced movement.
Many cities have derived the dimensions of their streets from the dimensions of a donkey.

Donkey on the streets in Fez, Morocco. © Blurf | Dreamstime.com

Susan Orlean[4] studied in 2009 the old city of Fez in Morocco. According to her, Fez is the largest old city in the world. All its houses are densely populated, its markets are crowded and it is a bustling city. Orlean reports that in 2009, about 100,000 people used donkeys as regular and daily means of mobility and transportation in ancient Fez. The donkeys were used to transport loads, remove garbage, evacuate the sick and injured, for riding, for construction work, and operate devices that require the rotation of wheels, for various activities, such as grinding with millstones, storing oil, pumping or squeezing.

Stair streets in the Land of Israel

Not only Fez in Morocco is made according to the size of a tediously loaded donkey. In the cities of the Land of Israel as well, as in many cities in the Mediterranean basin, the donkey was the criterion for determining the minimum dimensions of the street.[5]

Jerusalem, Acre, Safed, Nazareth, Jaffa and other settlements were built on a hill or down a mountain, on the relatively moderate side. The layout of the settlement was such that streets that were built parallel to the elevation lines were used for commerce, while the streets built perpendicular to the elevation lines were made of stairs adapted for donkey walking. At first, these were connecting streets, along which were entrances to residential complexes and public buildings (religious buildings, schools, bathhouses, etc.)

With time, when activity increased in the city, and the population density increased greatly, mainly in cities surrounded by wall, commerce also slipped to the stair streets, albeit in a less intense manner. An exception is the stairs market street in Jerusalem, which is on the ancient route of the Roman Decumanus (west-east axis in the city planning). And yet in Jerusalem, too, there is more commercial activity on the streets without stairs, which cross it parallel to the route of the valley from north to south (Hagai St., Cardo/ Beit Habad), and open-air commercial activity on the stair -streets perpendicular to the slope (excluding David Street). These cities are also characterized by the fact that towards the street the houses stand densely, side by side, leaving very narrow passages between them, in terms of cities that allow the movement of carriages or motor vehicles. Behind the built façade there are, quite often, large courtyards open to the sky, inner gardens, and quite a bit of light and air.

In Jerusalem, a considerable effort was made to build the streets that are perpendicular to the slope with moderate stairs with low rise (10-13 cm), with a tread as wide as possible. In places where there is no option for a tread that fits a

4 Source: http://www.smithsonianmag.com/travel/shere-donkeys-Deliver-Morovvo.html

5 During the years 2008-2009, I was a partner in a very comprehensive and thorough survey, the subject matter of which was the accessibility of the Old City of Jerusalem to people who move around with the help of personal devices - crutches and walking sticks, walkers of all kinds, wheelchairs and mobility scooters. The physical survey was conducted by Dr. Judith Bendel of Access Unlimited Association; In the analysis of the survey results took part Dr. Judith Bendel, Dr. Avi Ramot from the Israeli Center for Accessibility, and I, as part of my role as the Jerusalem Municipality's accessibility consultant. Simultaneously with the physical survey, I conducted in those years in the Old City a survey of housing conditions of families that have a person with a severe mobility disability. The survey was made possible thanks to the dedication of Shaher Shabana, who mediated between me and the families, accompanied me on all home visits and served as my interpreter, all voluntarily. The description of the last four cities is based on repeated visits, without a proper survey.

A typical stairs street in Jerusalem © Evgeniy Fesenko | Dreamstime.com

full donkey's tread, i.e. a tread whose depth reaches 110-125 cm, the tread size is reduced according to the donkey's steps. A donkey's step ranges from 37 to 42 cm. Thus, the stairs module in the Old City of Jerusalem is based on 37-42 cm. In other words, the tread according to one step, two steps or three steps of an average domestic donkey. The spaces maintained between one set of stairs and the next set are derived from two influencing factors: location and width of the entrances to the buildings at the side of the public staircase, and the minimum surface area required to position the animal and load or unload it.

The geometry of the street: width, height, slope

The slope of a staircase is derived from the natural topography: while the rise (height) of the step maintains a constant measure of about 13 cm, the degree of width of the tread (the step tread) is adapted to the natural slope. For a narrow tread of 42 cm., suitable for the movement of pack animals, a slope is obtained in a ratio of approximately 13/42 = 1:3. For comparison: the conventional slope for a comfortable and standard staircase, with a tread of 30 cm and a rise of 15 cm, is a ratio of 1:2. A reasonable pass, for a person pushing cart or using a wheelchair, is a length-to-height ratio between 1:9 and 1:11 respectively, so that a sloping surface 126 cm long (3 steps 42 cm wide) makes it possible to overcome one step of 13 cm high.

In the Old City of Jerusalem, the width of the widest streets reaches 5 meters. There are very few such streets, mainly in the Christian Quarter along the Eastern Wall, between Zion Gate and the Dung Gate. These streets were built when harnessed carriages, or cars, were already traveling in Jerusalem. The average width of the large market streets in Jerusalem reaches three to four meters from wall to wall, and when the stores open and the merchants take their merchandise out to the area in front of the store as is the custom, there is more-or less a two-meter road width left for the public passage, more than enough for the passage of people passing by those who stop to bargain. On non-commercial streets, the average size reaches two meters from wall to wall, and often drops to a meter and a half - just to allow the passage of a donkey and its rider. There is no significant difference in the width of the streets, between those built along the elevation lines and the streets and those that are stretched like stairs perpendicular to the slope.

The end of the donkey era – adjustment to wheels

In the course of the 20th century, the use of wooden carriages/wheelbarrows, carried on three or four wheels, replacing the donkeys, took root in Jerusalem and Acre[6], although their carrying capacity was considerably lower than that of the humble pack-animals.

The dimensions of the carts are somewhat similar to those of the donkey, adapting themselves to the conditions of the terrain - the width of the cart between the wheel axles reaches 67 cm, the length of the cart between the point of contact of the wheels with the ground reaches 95 cm. The body of the carts is larger, and their length is up to 120 cm without the handles. It is customary to attach to the back of the cart a chain with a tire that serves as a brake on the descents - the cart pusher stands on the tire, thus adding his weight to the weight of the load and slowing the cart's speed down. It is interesting to note already here that the accepted dimensions between the wheel axles of scooters and wheelchairs are very similar to each other, and also to those of the freight carts. In wheelchairs, the distance between the points of contact with the ground is 60-70 cm depending on the model, in scooters this size ranges from 90 to 105 cm, depending on the model. The length of a standard wheelchair, including the foot rest and handles, is about 105 cm, and the length of a standard scooter is about 140 cm.

Many people are assisted in their daily lives by mobile devices on wheels. Pushing baby carriages and wheelbarrows to transport goods, dragging suitcases on wheels and shopping carts, traveling in low-speed personal vehicles, such as

6 I have not seen such carts in Jaffa, Safed and Nazareth, although they may exist.

Segway or scooters of various kinds, as well as those who regularly use walkers and wheelchairs.

All of those find it very difficult to climb stairs with the help of these devices. There are no devices that are reasonably priced that can imitate the movement of the donkey up the stairs - wheel after wheel. First the device must be tilted backwards so that the front wheels climb first the stair, and pull behind them the rear wheels. Raising the device up the stairs requires a lot of driving force, which will manage to roll the weight from a position of complete stopping to a vertical upward movement, which overcomes the average height difference of 13 cm.

Descending the stairs actually requires a great deal of effort in braking, since tilting the device in the direction of the descent may, God forbid, cause uncontrolled rolling down the stairs. The encounter bump with the landing surface is also added to the downward movement.

And finally, the traveler's safety. The streets are stretched over the natural ground slope, depending on the shortest route between different foci of the Old City. The slope of a terraced street ranges from 10% (11-13 cm rise, with a 125 cm tread) to a 33% slope (11-13 cm rise and 37 cm tread). When ramps are placed on such stairs, one gets too steep a route for a person with a walking disability, who has difficulty holding himself back downhill. For this reason, it can be seen in almost all the streets where sloping ramps have been installed, that the common practice is to lay a rather narrow slope stone across the tread of the stair, in such a way that it does not reach from one step nose to the next step nose. A route is obtained that a person with a disability is unable, in fact, to overcome on his own, and is forced to be assisted by another person to push him. The assisting person must also hold back the mobility device against slipping down the stairs. In order for the assistant to be able to gain strength and overcome the steep ascent, it is customary to allow him as many breaks as possible for rest on horizontal surfaces. Hence, clever planning of a sequence of slopes will be done so that they are shifted every few steps from their route sideways, allowing horizontal surfaces between them, both for rest and for breaking the sequence of the track, so that the pace of movement on them will be as slow as possible. The shift also prevents children and other reckless people from speeding downhill, riding bicycles, or all sorts of devices that children build for themselves, and whose whole purpose is fast, not to say wild, gliding on dangerous slopes.

Laying slope stones in a method designed to hold back the speed of mobility devices on wheels downhill, and whose prevalence proves to be useful, makes it very difficult to drive any motor vehicle, even if it is narrow and short and has very high passability. Off-road vehicle with relatively large wheels, propulsive power in difficult terrain conditions and very good maneuverability is used inside ancient cities, of the type I am describing here, to evacuate the sick and injured, transport goods and heavy objects, or to evacuate garbage carts and so on.

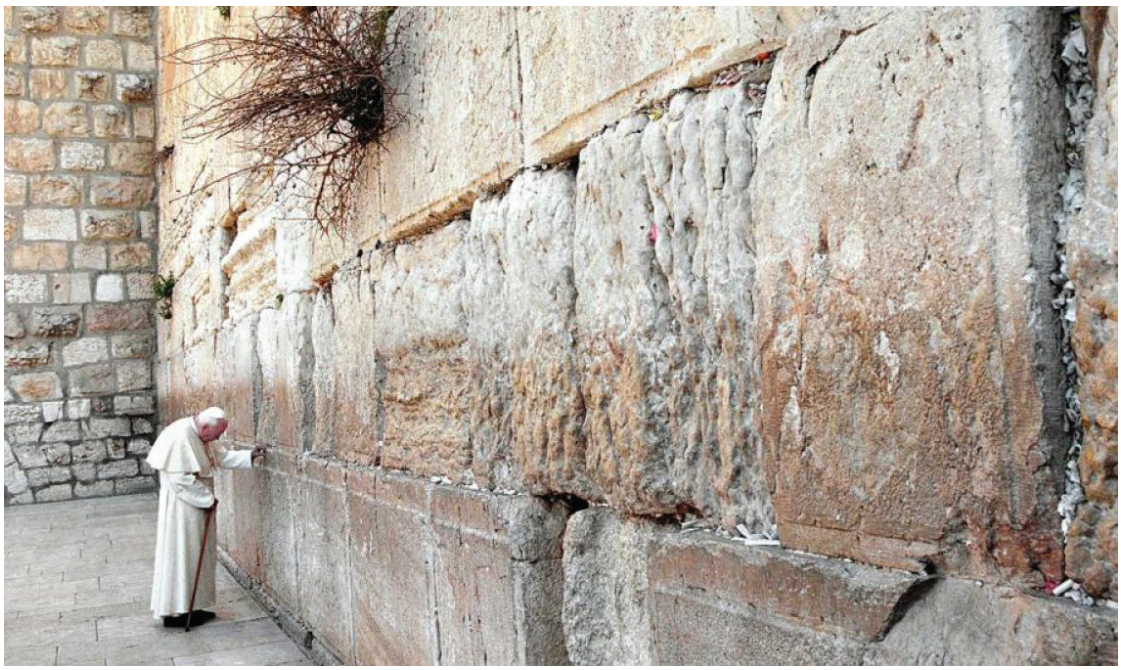
The trouble is that there is no vehicle narrow enough, as wide as a laden donkey - that is, 120 cm at most, suitable for transporting a sick or injured person to an ambulance waiting outside the system of terraced streets. The narrowest model that can tackle the donkey stairs, and where a driver can be seated and next to him a stretcher of a wounded man, reaches a width of up to 142 cm.[7] Until

7 The measure was learned from Yossi Ben Shachar, the MDA ambulance driver who uses an MULE type all-terrain vehicle (ATV).

the visit of Pope John Paul II to Jerusalem, no one thought of trying to put in a motorized vehicle that would carry passengers along the terraced streets of Jerusalem's Old City. Until then, the only motor vehicle that entered the terraced streets was a particularly narrow service tractor (about 100 cm wide), with high wheels and thick tires, towing a cart, and its function was to transport building materials and remove garbage.

Lessons learned from the Pope's visit, March 2000

Pope John Paul II's visit to the Western Wall in Jerusalem in March 2000 was accompanied by multiple preparations by the city leaders, as part of the Pope's personal security system, who moves from place to place in an armored personal vehicle nicknamed[8] Popemobile. In order for the armored vehicle (built especially for the visit to the Old City) to be able to travel on the terraced streets leading from the Christian Quarter to the holy places, it was inevitable to add stone ramps to the existing stairs. The route was carefully selected, and included the streets that could contain both the stone ramps and a route of stairs of reasonable width on their side, given of course the nature of the façade. On the side of a sealed wall, room was left for the passage of one person, and on the side of the store openings, the activity near the store was also taken into consideration.



The Pope's visit to the Western Wall. Photo: Menahem Kahana (published on the Irish Times)

Today, the ramps serve well the residents of the Old City: they are used for the ministry cars of very important people, who live in the city or come from outside, for the ride of security and rescue vehicles, for the ride of ATVs that tow garbage carts or construction materials, and for the ride of vehicles of people with disabilities..

8 The practice of driving the Pope in an armored glass box assembled on top of an armored "commercial" vehicle began in 1984, after an attempted assassination of the Pope.

The size of the stone ramps installed in honor of the Pope on top of the donkey steps is adapted to the particularly narrow vehicles built for the Pope, approximately 140 cm wide. The slope of the stone ramps is approximately 18%, in accordance with the rise size of the existing donkey steps. The resulting slope is too sharp for those who try to overcome it on their own in a motor-less wheelchair, but it is possible for owners of personal motorized mobile devices (wheelchairs, scooters, Segway, etc.). Pedestrians continue to use the remaining stairs on either side of the sloping route. Wherever possible, handholds were installed on the staircase sides.

Of course, not everywhere can ramps be built as wide and comfortable as those built for the Pope. For about two decades the municipality has been doing its best to deal with the introduction of wheeled vehicles into the streets[9], so that they will replace the donkeys, which have gradually become unwanted, due to the dirt they leave behind, the unpleasant odor, and the reluctance of a crowd which is unaccustomed to rubbing shoulders with the smart pack animals.

The main conflict that has arisen, once the traffic has moved from donkeys to carts on wheels, is the need for wheel accessibility, that is, the requirement for ramps, as opposed to the interest of pedestrians, who are able to climb stairs, to keep for themselves as much of the original stairs width as possible, whose layout, as stated, is most convenient for moderate walking. At times when the streets are filled with a dense crowd of visitors, there is a growing need to allow security and rescue forces to move through the streets quickly, and on the other hand there is a growing need of the crowd that moves in dense masses to march fluently, without tripping over local slope stones.

Accessibility is a resource

It seems to me impossible to resolve the difficulty of transporting goods and people, who do not climb stairs on their feet, without inserting mobile devices with high propulsion, high braking force, ability to maintain stability up or down a stairway, and yet maintain the safety, comfort and safety of a passenger with a disability, an injured person, a woman in labor, or a person who is having a heart attack. Furthermore, it is no longer possible to avoid the use of a motorized vehicle, which is able to “speed “ through the streets in relation to the running of pedestrians, and whose function is to maintain public safety.

Terraced cities are home to residents who cope with great difficulty with mobility disability, and need accessibility adjustments in order to be able to leave their home and return to it on their own, or with the help of an escort. Due to the low accessibility to motorized vehicles, only those, who are unable to move to more comfortable living conditions remain. There are also only few hotels in these areas. Tourists prefer to find accommodation at an easy-to-reach place, and tour inside the unique city that ignites the imagination, as long as they have the strength, curiosity, and ability to move on foot.

9 The first slope stones were installed to the best of my knowledge in 1985, on David Street, in a section that descends from the Jaffa Gate to Hagai Street. The merchants claim that they also changed the stairs’ pace, spoiled the rhythmic structure that suited the donkeys, and with the slope stones they did create a route for the goods carts as well, but an obstacle and a lot of trouble for the tens of thousands of tourists, who visit the market street every year.

Business owners are being pushed to specialize in the sale of "lightweight" goods that can be transported in handcarts. The local authority is forced to compromise on garbage removal and street maintenance methods of the kind that make modernization very difficult. The result is a vicious cycle of deterioration and neglect of the public space, which is almost impossible to manage. The cycle of poverty of the residents, who were left behind in an environment with a low level of municipal service, is expanding, and with it the number of visitors, who walk through the alleys increases, but refrain from staying at the place after nightfall or doing business there.

The commerce is characterized by souvenir shops and stores that provide the basic needs of the locals. Almost all types of businesses and other public institutions leave the inaccessible space. The departure of necessary public institutions and businesses that may also serve as a source of livelihood for residents increases the neglect, since people who live outside the special compound stop reaching it for the purpose of settling various matters, and it is pushed out of the public consciousness. Little by little, they also stop coming to the markets or the entertainment sites.

That same thing happened to the cities of Acre, Safed, Tiberias, and Jaffa, and even to the Old City of Jerusalem. I suppose the same is true of other cities, which in the past have relied on donkey traffic, and now fail to allow, in their terraced streets, traffic with the help of mobile devices on wheels that are not set for efficient and quality travel on stairs.

All those who are interested in reviving the special fabric of the cities of donkeys, and in making these ancient cities accessible to a lifestyle that includes the traffic of mobile devices on wheels – even if they are personal, narrow-sized, and of low speed, must probably unite and propel the wheels of research and development. They should encourage the manufacturing and sale of devices that can cope with special terrain conditions, and with the demands of customers who live in those places, when each of them individually does not have enough purchasing power. The product market needs to be global. There are quite a few customers in the world, but they are scattered across many cities, in countries that unfortunately are often hostile to each other. Israel, which has very few natural resources, but many cultural, landscape and heritage resources, could be a spearhead if it only understood that without introducing sophisticated traffic systems into the ancient spaces, there is no chance for their growing into accessible attractions for those tens of thousands of visitors who are just waiting at the doorstep. To strengthen my words, I would say that the concept of "accessibility is a resource" has succeeded in increasing by dozens of times the number of visitors to Masada, Rosh Hanikra, the Agamon Hahula site and other nature, landscape and heritage sites that have enabled the entry of personal and motorized mobile devices.

There is no reason that the concept of accessibility that I presented in this article will not work in the ancient donkey cities of the Land of Israel as well. Sophisticated mobility devices will allow us to preserve, for future generations, the donkey streets and their wonderful stair rhythm, as they are. Without such devices, extinction is expected for some of the stair streets. Unfortunately, it is already possible to see how more and more stair streets are becoming slope roads for cars; and they also endanger both the vehicle drivers and the pedestrians, who barely cope with the steep slopes.