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LOKIBASE: The Device for Seismic Isolation of Pallet Racking Systems—Optimization Analysis

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Abstract: LOKIBASE is a non-linear isolator/dissipator device to protect pallet racking systems against the earthquake. LOKIBASE consists of the following main components: (1) two slider devices on which a rubber membrane is set up (LOKI devices). LOKI devices are linear displacement dependent ones; (2) a cylindrical beam damper ("CANDLE" device). The "CANDLE" device is a non-linear displacement dependent one; (3) two anti-lifting devices ("UP-LIFT" devices); (4) a fuse plug (see www.lokibasedevice.com). The main work which is the purpose of the paper, is the optimization of the behavior of an isolator/dissipator device to mitigate the seismic action on special structures, where the stiffness values are very different in the main cross-aisle and down-aisle directions. Under seismic action, in these structures it is very important to reduce the value of the forces at the Limit state for the safeguard of human life (SLV) in the down-aisle direction as much as possible and simultaneously to use the highest damping value allowed by the building rules to reduce the LOKIBASE displacement at the Limit state for collapse prevention (SLC) in the cross-aisle direction. The goal was achieved through a cylindrical device made of stainless steel (AISI304) with an optimized shape, under large displacement during seismic action.

Key words: LOKIBASE, "CANDLE", pallet racking systems, cylindrical beam damper, holed cylindrical beam damper.

1. Introduction

1.1 LOKIBASE—The Device for Seismic Isolation of Pallet Raking Systems

LOKIBASE is a special device to protect pallet racking systems against the earthquake. LOKIBASE consists of the following main components [1]:

- two slider devices on which a rubber membrane is set up (LOKI devices). LOKI devices are linear displacement dependent ones;
- a cylindrical beam damper ("CANDLE" device). The "CANDLE" device is a non-linear displacement dependent one;
- two anti-lifting devices ("UP-LIFT" devices);
- a fuse plug.
- In the following Fig. 1 the standard configuration is shown.

1.2 How Does LOKIBASE Work?

LOKIBASE is a patented anti-seismic device (Ferrari-Girardini). According to the information in the Section 11.9.1 of Ministerial Decree of 17 January 2018 [2], it can be treated as a combination of two slider devices and a non-linear displacement dependent one. This anti-seismic device, placed in the isolation interface under rack structures, allows increasing the fundamental period of the structure itself and, subsequently, attenuating seismic actions. In LOKIBASE device, two slider devices, rigid in vertical direction and with negligible values of resistance to the friction in horizontal directions, thanks to marble bearing system, allow supporting vertical loads and decoupling sliding planes. Two conical rubber membranes and one cylindrical beam damper make a non-linear displacement-dependent device, which enables the control of pallet racking system displacements under seismic action. LOKI device does not bear the tensile forces, which should act on it under seismic action and certain use conditions of the pallet racking system. For these, for each upright frame two "up-lift" devices

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(anti-lifting) are provided.

To ensure adequate comfort under conditions of normal use and avoid small oscillations during picking operations, a special seat for engagement with one fuse plug is provided on "up-lift" devices. This fuse plug is calibrated to withstand horizontal actions compatible with ordinary loading and unloading operations in compliance with the constrains imposed by anti-seismic protection techniques adopted (seismic isolation). Only one fuse plug for upright frame is provided.

1.3 Purpose and Structure of the Paper

Purpose of the paper is optimizing the shape of the cylindrical stainless steel (AISI304) damper of the LOKIBASE device, an isolator/dissipator for the protection of pallet racking structures form earthquakes, to reduce the value of the forces at the Limit state for the safeguard of human life (SLV) [2] in the down-aisle direction as much as possible and simultaneously to use the highest damping value allowed by the building rules to reduce the LOKIBASE displacement at the Limit state for collapse prevention (SLC) [2] in the cross-aisle direction.

Chapter 2 summarizes the data of the standard LOKIBASE device.

A shape optimization analysis of the cylindrical damper is presented in Chapter 3.

In Chapter 4, conclusions are given.

2. Data of the Standard LOKIBASE Device

The standard LOKIBASE device is characterized by Refs. [3-6]:

- LOKI device stiffness k = 6 N/mm;
- large displacement of the engaged length at the top of the cylindrical beam damper;
- cylindrical beam damper with constant circular cross-section and non-zero friction.

Neglecting the vertical constraint contribution (due to the horizontal strut at the bottom of the upright frame) in the cylindrical beam damper flexural bending (theoretical configuration only) the value of the force which acts on the LOKIBASE device $F^{c}_{2,TH,LOKIBASE}$ is higher than $F^{c}_{2,LOKIBASE}$ (horizontal force on the standard LOKIBASE device, Table 1). The two values are given below:

$$F^{c}_{2,TH,LOKIBASE} = 3{,}804 \text{ N} \quad (1)$$

$$F^{c}_{2,LOKIBASE} = 3{,}484 \text{ N} \quad (2)$$

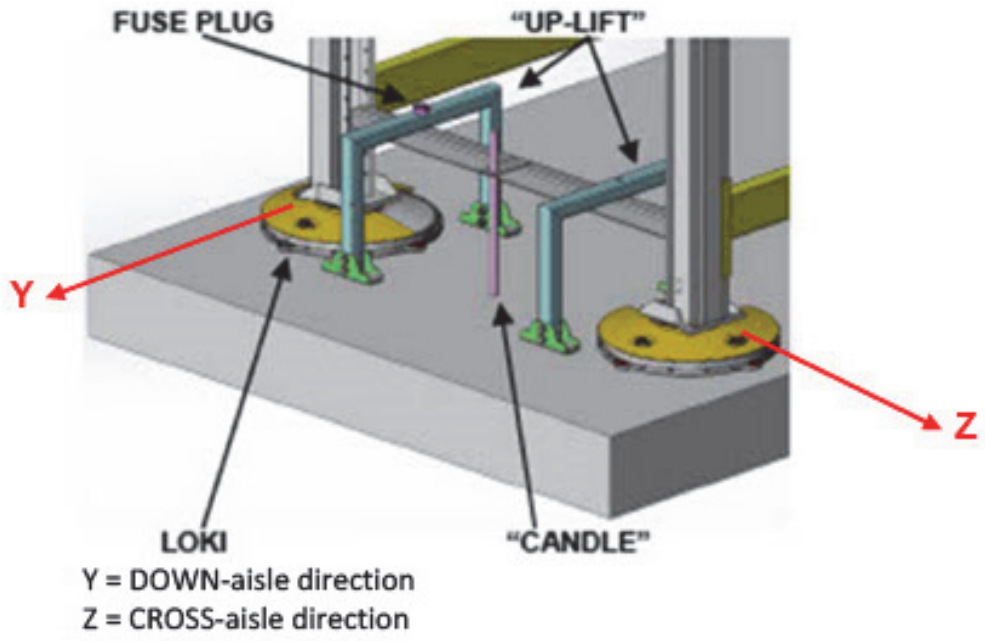


Fig. 1 LOKIBASE standard configuration.

Table 1 Theoretical bilinear parameters of the standard LOKIBASE device.

Parameter	Value	Note
$d^{c}_{el,LOKIBASE}$ (mm)	8.7	Displacement in the first branch of the load test where the behavior of LOKIBASE device is linear. A value $d_2/20$ is taken
$F^{c}_{el,LOKIBASE}$ (N)	414	Force for $d^{c}_{el,LOKIBASE}$ displacement in the first branch of the load test where the behavior of LOKIBASE device is linear
$d^{c}_{e1,LOKIBASE}$ (mm)	49.8	Displacement of LOKIBASE device at the intersection point of the r_1 and r_2 straight lines
$F^{c}_{1,LOKIBASE}$ (N)	2,371	Force on LOKIBASE device at the intersection point of the r_1 and r_2 straight lines
$d^{c}_{2,LOKIBASE}$ (mm)	174	Maximum design displacement of the LOKIBASE device at the Limit state for collapse prevention SLC
$F^{c}_{2,LOKIBASE}$ (N)	3,484	Force on LOKIBASE device for the $d^{c}_{2,LOKIBASE}$ displacement, in the third cycle of the load test
$K^{c}_{1,LOKIBASE}$ (N/mm)	47.6	Elastic stiffness (first branch) of LOKIBASE device
$K^{c}_{2,LOKIBASE}$ (N/mm)	9.0	Post-elastic stiffness (second branch) of LOKIBASE device
$K^{c}_{sec,LOKIBASE}$ (N/mm)	20.0	Secant stiffness of LOKIBASE device
μ_{LOKI}	0.15%	Friction coefficient LOKI devices
$E_{d,2LOKI}$ (J)	114	Energy dissipated by two LOKI devices
$E^{c}_{d,damper}$ (J)	780	Energy dissipated by the cylindrical beam damper
$E^{c}_{d,LOKIBASE}$ (J)	895	Energy dissipated by LOKIBASE device
$\xi^{c}_{e,LOKIBASE}$	0.235	LOKIBASE device equivalent viscous damping coefficient
Note	[c]: Cylindrical beam damper with circular cross section diam. 16 mm.	

3. Optimization Analysis of the LOKIBASE Device

3.1 Introduction

The theoretical optimization analysis shown below aims to optimize the behavior of LOKIBASE device in order to [1, 7-10]:

- reduce the force under earthquake excitation in the down-aisle direction (*Y* in Fig. 1);
- control the maximum value of the displacement in the cross-aisle direction (*Z* in Fig. 1).

For the maximum displacement d_2, a comparison of the horizontal force $F^{hc}_{2,DOWN,LOKIBASE}$ acting in down-aisle direction (the weakest), on the optimized LOKIBASE device and the horizontal force acting in the same direction on the LOKIBASE device with cylindrical beam damper ($F^{c}_{2,TH,LOKIBASE}$ given in Eq. (1) in the theoretical configuration, and $F^{c}_{2,LOKIBASE}$ given in Eq. (2) in the standard configuration) is made. The data about the theoretical bilinear cycle of the optimized LOKIBASE device are given. In Fig. 2 the analyzed equipment is shown.

3.2 Optimization Analysis of the LOKIBASE Device

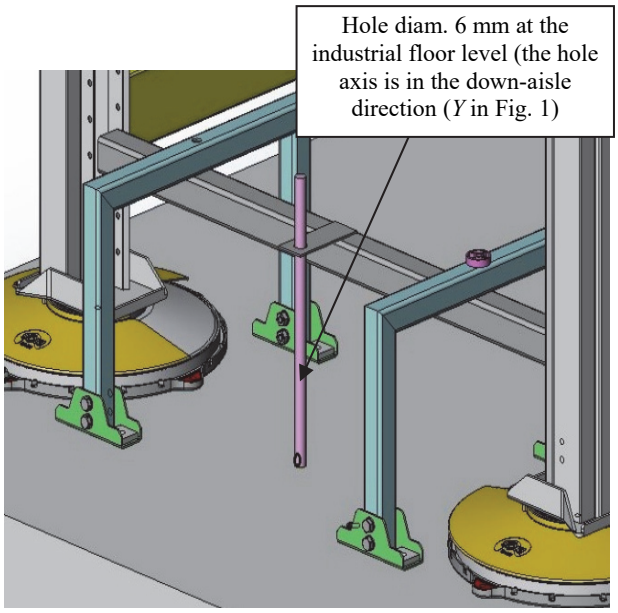
The theoretical optimization analysis takes account of:

- LOKI device stiffness k = 5 N/mm;
- large displacement of the engaged length at the top of the cylindrical beam damper;
- a hole of special size and its position on the cylindrical beam damper.

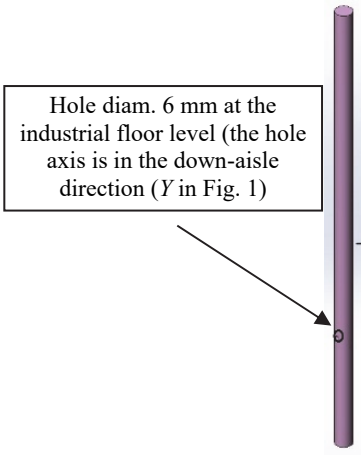
Now, for the maximum displacement d_2 and two LOKI devices with a k value of 5 N/mm, a comparison of the horizontal force $F^{hc}_{2,DOWN,LOKIBASE}$ acting in down-aisle direction (the weakest) on the optimized LOKIBASE device and the horizontal force acting in the same direction on the LOKIBASE device with cylindrical beam damper ($F^{c}_{2,TH,LOKIBASE}$ given in Eq. (1) in the theoretical configuration, and $F^{c}_{2,LOKIBASE}$ given in Eq. (2) in the standard configuration) is made.

$$\frac{F^{hc}_{2,DOWN,LOKIBASE}}{F^{c}_{2,LOKIBASE}} = \frac{2,772}{3,484} = 0.79 \quad (3)$$

$$\frac{F^{hc}_{2,DOWN,LOKIBASE}}{F^{c}_{2,TH,LOKIBASE}} = \frac{2,772}{3,804} = 0.73 \quad (4)$$



View of the equipment and detail about the holed cylindrical beam damper installation



Holed cylindrical beam damper

Fig. 2 LOKIBASE analyzed equipment.

Table 2 LOKI device data by test.

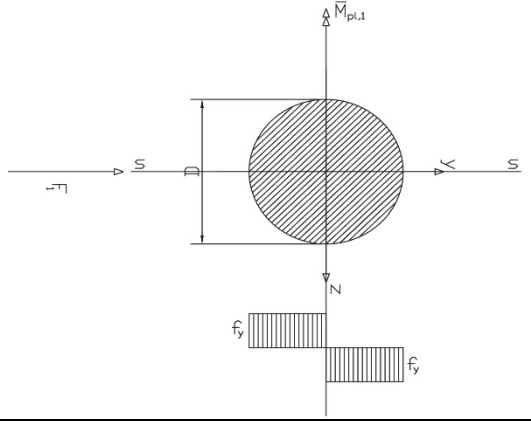
k (N/mm) = 5.0	LOKI stiffness
K (N/mm) = 10.0	K=2×k=stiffness of two LOKI devices
$e_{d.LOKI}$ (J) = 57.1	Energy dissipated by LOKI due to friction
$E_{d.2.LOKI}$ (J) = 114.1	Energy dissipated by two LOKI devices due to friction
d_2 (mm) = 174.0	Maximum design displacement of LOKIBASE at the SLC

Table 3 Data of the standard cylindrical beam damper(1) by test.

$F^c_{2,damper}$ (N) = 1,397.5	Force at the maximum displacement d_2
$E^c_{d,damper}$ (J) = 780.5	Energy dissipated in the third cycle

Note (1) ^{c}: Standard cylindrical beam damper with circular cross-section diam. 16 mm.

Table 4 Theoretical data of the standard cylindrical beam damper(1).

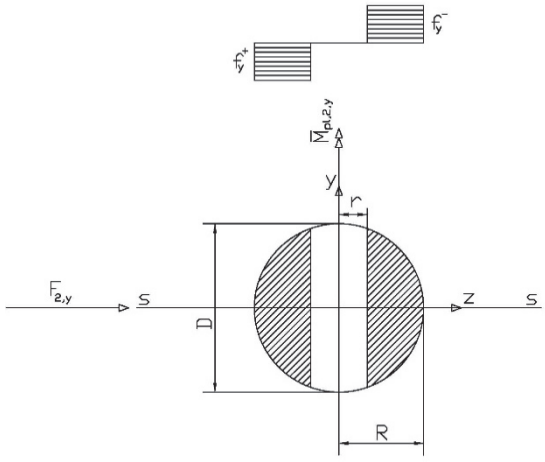


D (mm) = 16	Diameter of the circular cross-section
W^c_{pl} (mm^3) = 683	Plastic section modulus of the circular cross-section

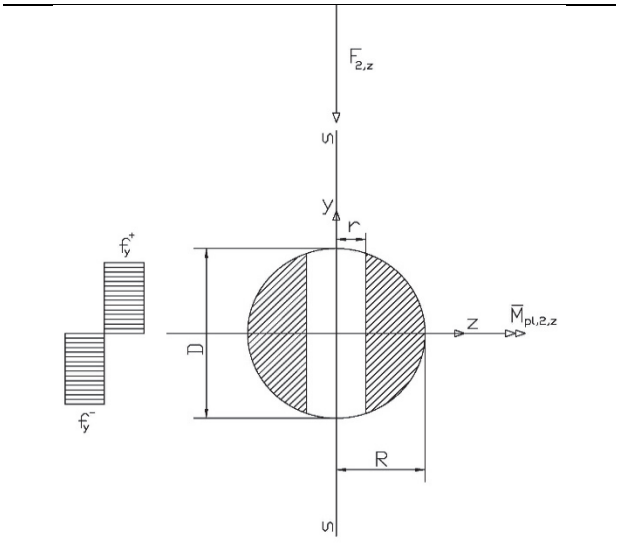
where: $W^c_{pl} = \frac{D^3}{6}$

Note (1) ^{c}: Standard cylindrical beam damper with circular cross-section diam. 16 mm.

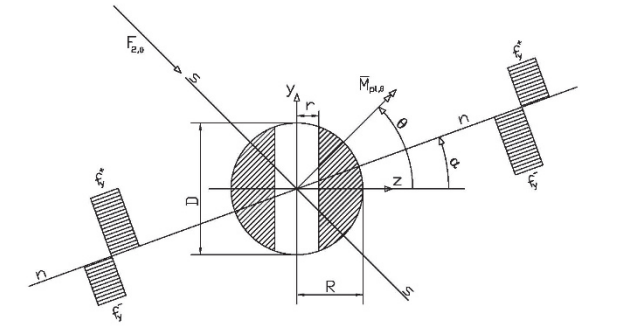
Table 5 Theoretical data of the holed cylindrical beam damper.



Bending moment **M** about the strong y-axis



Bending moment **M** about the weak *z*-axis



Bending moment **M** about the θ-axis

Theoretical data of the circular gross cross-section(2)	
D (mm) = 18	Diameter of the holed cylindrical beam damper
$W_{\mathrm{pl}}^{\mathrm{hc}}$ (mm^3) = 972	Plastic section modulus of the circular gross cross-section

where: $W_{\mathrm{pl}}^{\mathrm{hc}} = \frac{D^3}{6}$

Note (2) hc Holed cylindrical beam damper diam. 18 mm.

Main theoretical data of the holed circular cross-section(2)	
D (mm) = 18	Diameter of the holed cylindrical beam damper
d (mm) = 6	Diameter of the hole in the holed cylindrical beam damper
$W_{\mathrm{pl,y}}^{\mathrm{hc}}$ (mm^3) = 815	Plastic section modulus of the holed circular cross-section about the strong y-axis
$W_{\mathrm{pl,z}}^{\mathrm{hc}}$ (mm^3) = 468	Plastic section modulus of the holed circular cross-section about the weak z-axis

where:

$$W_{\mathbf{pl,y}}^{\mathbf{hc}} = \frac{D^3}{6} * (\cos\psi)^3 \; where: \psi = arcsen\frac{d}{D}$$

$$W_{\mathrm{pl,z}}^{\mathrm{hc}} = \frac{D^3}{6} - \frac{D^2 * d}{4} + \frac{d^3}{12}$$

Note (2) hc Holed cylindrical beam damper diam. 18 mm.

Theoretical plastic section modulus of the holed circular cross-section(2) about the neutral n-axis	
D (mm) = 18	Diameter of the holed cylindrical beam damper
d (mm) = 6	Diameter of the hole in the holed cylindrical beam damper
$W_{\mathrm{pl},\alpha}^{\mathrm{hc}}$ (mm^3) = See Fig. 3	Plastic section modulus of the holed circular cross-section about the n-axis

where

$$\boldsymbol{W_{pl,a}^{hc}} = 2 * \left(\left|\frac{R^3*(sin\,\alpha)^2*(cos\,\alpha)^2}{6} - \frac{r^3*tan\,\alpha*sin\,\alpha}{6}\right| + \left|\frac{R^3*cos\,\alpha}{3} + \frac{R^3*(cos\,\alpha)^4}{6} * (1 - 3 * (1 + (tan\,\alpha)^2) - 2 * (tan\,\alpha)^4)\right| + \left|\frac{R^2*cos\,\alpha}{6} * \left(2 * R - 3 * r + \frac{r^3}{R^2}\right) + \frac{sin\,\alpha}{3} * (R^2 - r^2)^{3/2}\right| + \left|\frac{R^3}{6} * (2 * (sin\,\alpha)^4 \cdot (cos\,\alpha)^4 + 3 * (cos\,\alpha)^2 + (sin\,\alpha)^2 * (cos\,\alpha)^2) + \frac{r^3}{6} * \left(cos\,\alpha - sin\,\alpha * tan\,\alpha - \frac{3*R^2}{r^2} * cos\,\alpha\right) - \frac{sin\,\alpha}{3} * (R^2 - r^2)^{3/2}|\right)$$

for $a \le a^* = arccos\left(\frac{r}{R}\right)$

and

$$\boldsymbol{W_{pl,a}^{hc}} = 2 * \left(\left|\frac{R^3 * cos\,\alpha}{3} - \frac{sin\,\alpha}{3} * (R^2 - r^2)^{\frac{3}{2}} + \frac{r_i}{6} * (r^2 - 3 * R^2) * cos\,\alpha\right| + \left|\frac{R^2 * cos\,\alpha}{6} * \left(2 * R - 3 * r + \frac{r^3}{R^2}\right) + \frac{sin\,\alpha}{3} * (R^2 - r^2)^{\frac{3}{2}}\right|\right)$$

for $a > a^* = arccos\left(\frac{r}{R}\right)$

In the above formulas the neutral axis rotation, α, is given by:

$\boldsymbol{\alpha} = arctan\left(\frac{I_z^{hc}}{I_y^{hc}} * tan\,\theta\right)$ See Fig. 4.

where:

θ is the angle of rotation of the bending axis respect to the weak z-axis. See Table 5.

$$\boldsymbol{I_z^{hc}} = W_{el,z}^{hc} * y_{max} = W_{el,z}^{hc} * \sqrt{R^2 - r^2}$$

$$\boldsymbol{I_y^{hc}} = W_{el,y}^{hc} * z_{max} = W_{el,y}^{hc} * R$$

$$\boldsymbol{W_{el,z}^{hc}} = \frac{\pi * R^3}{4 * cos\,\varphi} + \frac{4 * r^4}{3 * R * cos\,\varphi} - \frac{4 * r^3}{3 * cos\,\varphi} - \frac{4 * R^2}{3 * cos\,\varphi} * \left(\frac{3}{8} * R * \varphi + \frac{5 * r}{8} * cos\,\varphi - \frac{1}{4} * r * cos\,\varphi * (sin\,\varphi)^2\right)$$

$$\boldsymbol{W_{el,y}^{hc}} = \frac{2 * R^3}{3} * \left(\frac{3}{4} * arcsen(cos\,\varphi) + \frac{5}{4} * sin\,\varphi * cos\,\varphi - \frac{1}{2} * sin\,\varphi * (cos\,\varphi)^3 - 2 * (sin\,\varphi)^3 * cos\,\varphi\right)$$

where:

$$\boldsymbol{\varphi} = arcsen\frac{r}{R}$$

In the all above formulas:

$\boldsymbol{R} = \frac{D}{2}$ and $\boldsymbol{r} = \frac{d}{2}$

Note (2) hc Holed cylindrical beam damper diam. 18 mm.

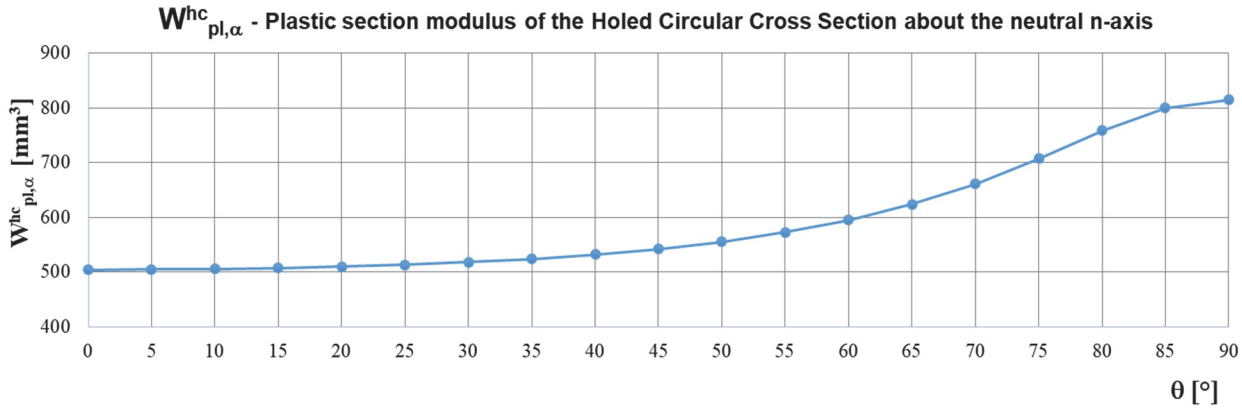


Fig. 3 Plastic section modulus of the holed circular cross-section about the neutral *n*-axis.

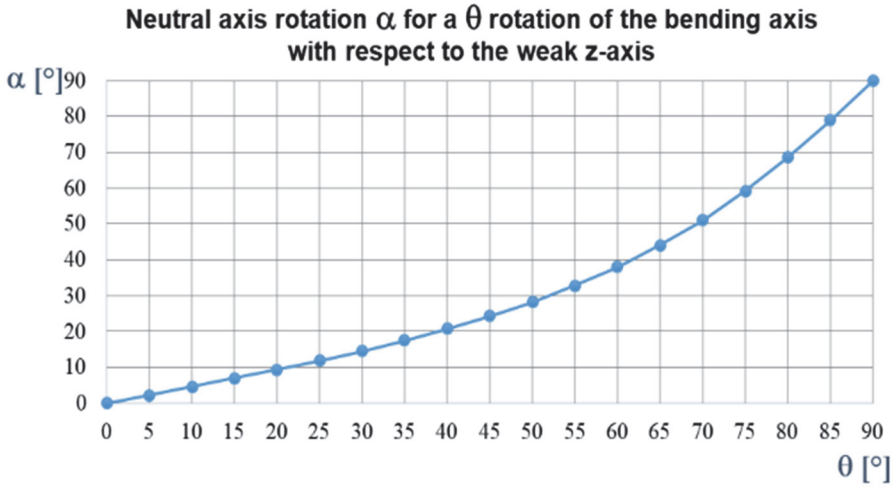


Fig. 4 Neutral axis rotation α for a θ rotation of the bending axis with respect to the weak *z*-axis.

Table 6 Adjustment factors A^{θ} for the force F^{hc}_2 at the top of the damper and for the energy $E^{hc}_{d,damper}$ (1), (2) in θ direction.

$A^{\theta} = W^{hc}_{pl,,\theta}/W^{c}_{pl}$ = See Fig. 5	Adjustment factor A for the force F^{hc}_2 at the top of the damper and for the energy $E^{hc}_{d,damper}$ in θ direction

Note (1) ^{c} Standard cylindrical beam damper with circular cross-section diam. 16 mm;
(2) ^{hc} Holed cylindrical beam damper diam.18 mm.

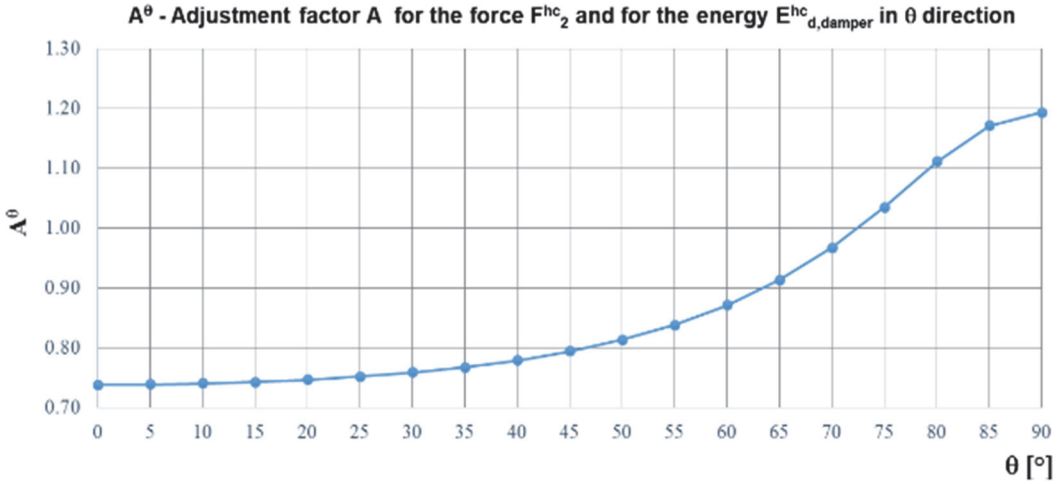


Fig. 5 Adjustment factor for the force F^{hc}_2 and for the energy $E^{hc}_{d,damper}$ in θ direction.

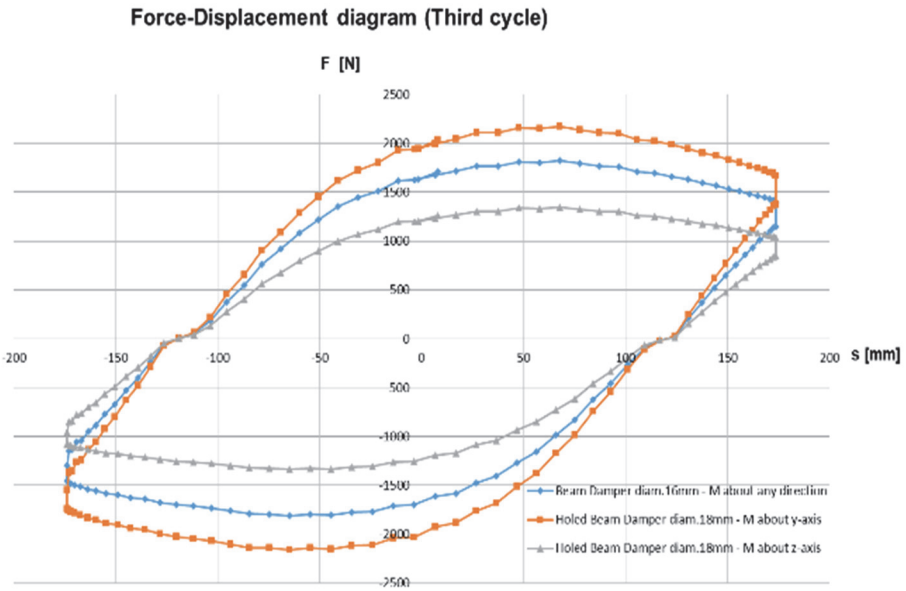


Fig. 6 Energy dissipated in the third cycle by the holed cylindrical beam damper (diam. 18 mm) in cross-aisle direction (cycle in orange) and in down-aisle direction (cycle in gray) versus the energy dissipated by the standard cylindrical beam damper (diam. 16 mm) in any direction (cycle in blue).

Table 7 Force applied to and energy dissipated by the optimized LOKIBASE device (holed cylindrical beam damper)(2) in CROSS-aisle direction.

$F^{hc}_{2.CROSS}$ [N] = 1,668	Force at the top of the holed cylindrical beam damper in CROSS-aisle direction
$F^{hc}_{2,CROSS,LOKIBASE}$ [N] = 3,408	Total force applied to LOKIBASE in CROSS-aisle direction
$E_{d,CROSS,2\ LOKI}$ [J] = 114	Energy dissipated by two LOKI devices due to friction
$E^{hc}_{d,CROSS,damper}$ [J] = 931	Energy dissipated by the holed cylindrical beam damper in CROSS-aisle direction, see Fig. 6
$E^{hc}_{d,CROSS,LOKIBASE}$ [J] = 1,045	Total energy dissipated by LOKIBASE device in CROSS-aisle direction
$\xi^{hc}_{e,CROSS,LOKIBASE}$ = 0.28	LOKIBASE equivalent damping coefficient in CROSS-aisle direction

Note (2) hc Holed cylindrical beam damper diam. 18 mm.

Table 8 Force applied to and energy dissipated by the optimized LOKIBASE device (holed cylindrical beam damper)(2) in DOWN-aisle direction.

$F^{hc}_{2.DOWN}$ [N] = 1,032	Force at the top of the holed cylindrical beam damper in DOWN-aisle direction
$F^{hc}_{2,DOWN,LOKIBASE}$ [N] = 2,772	Total force applied to LOKIBASE in DOWN-aisle direction
$E_{d,DOWN,2\ LOKI}$ [J] = 114	Energy dissipated by two LOKI devices due to friction
$E^{hc}_{d,DOWN,damper}$ [J] = 576	Energy dissipated by the holed cylindrical beam damper in DOWN-aisle direction, see Fig. 6
$E^{hc}_{d,DOWN,LOKIBASE}$ [J] = 690	Total energy dissipated by LOKIBASE device in DOWN-aisle direction
$\xi^{hc}_{e,DOWN,LOKIBASE}$ = 0.23	LOKIBASE equivalent damping coefficient in DOWN-aisle direction

Note (2) hc Holed cylindrical beam damper diam. 18 mm.

Table 9 Force applied to and energy dissipated by the optimized LOKIBASE device (holed cylindrical beam damper)(2) in θ direction.

$F^{hc}_{2,\theta}$ [N] = See Fig. 7	Force at the top of the holed cylindrical beam damper in θ direction
$F^{hc}_{2,\theta,LOKIBASE}$ [N] = See Fig. 8	Total force applied to LOKIBASE in θ direction
$E_{d,\theta,2LOKI}$ [J] = 114	Energy dissipated by two LOKI devices due to friction
$E^{hc}_{d,\theta,damper}$ [J] = See Fig. 9	Energy dissipated by the holed cylindrical beam damper in θ direction
$E^{hc}_{d,\theta,LOKIBASE}$ [J] = See Fig. 10	Total energy dissipated by LOKIBASE device in θ direction
$\xi^{hc}_{e,\theta,LOKIBASE}$ = See Fig. 11	LOKIBASE equivalent damping coefficient in θ direction

Note (2) hc Holed cylindrical beam damper diam. 18 mm.

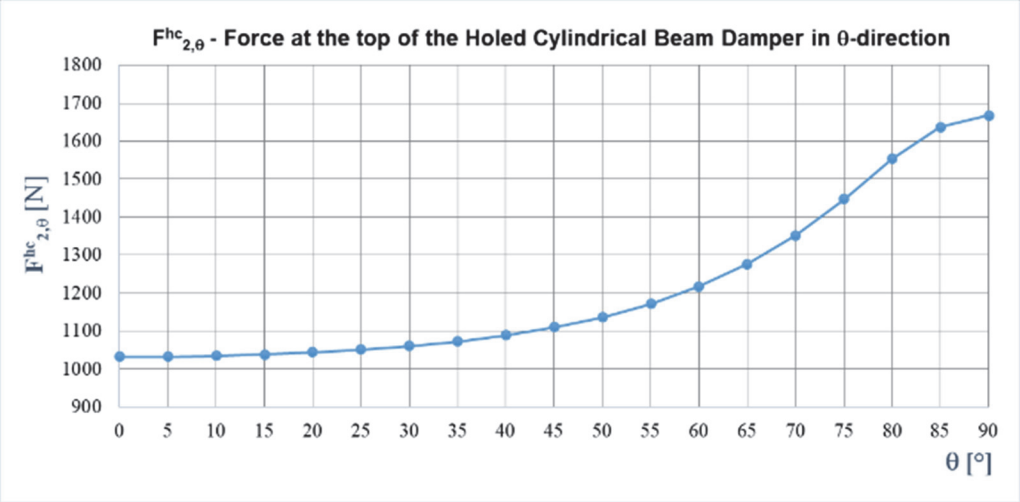


Fig. 7 Force at the top of the holed cylindrical beam damper in θ direction.

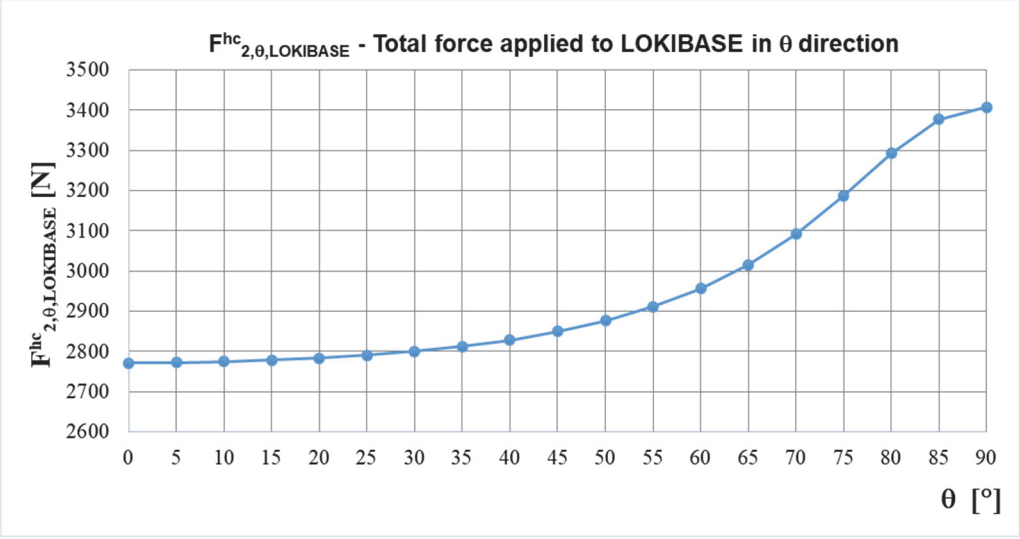


Fig. 8 Total force applied to LOKIBASE in θ direction.

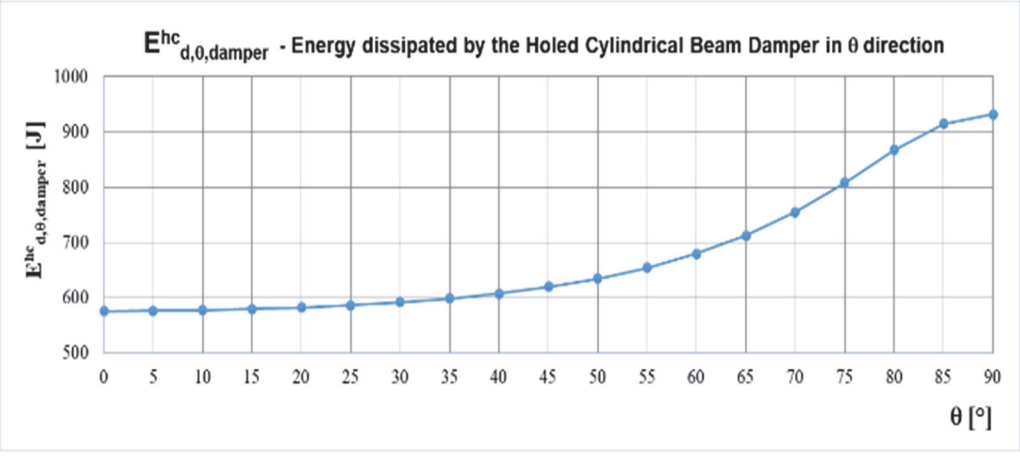


Fig. 9 Energy dissipated by the holed cylindrical beam damper in θ direction.

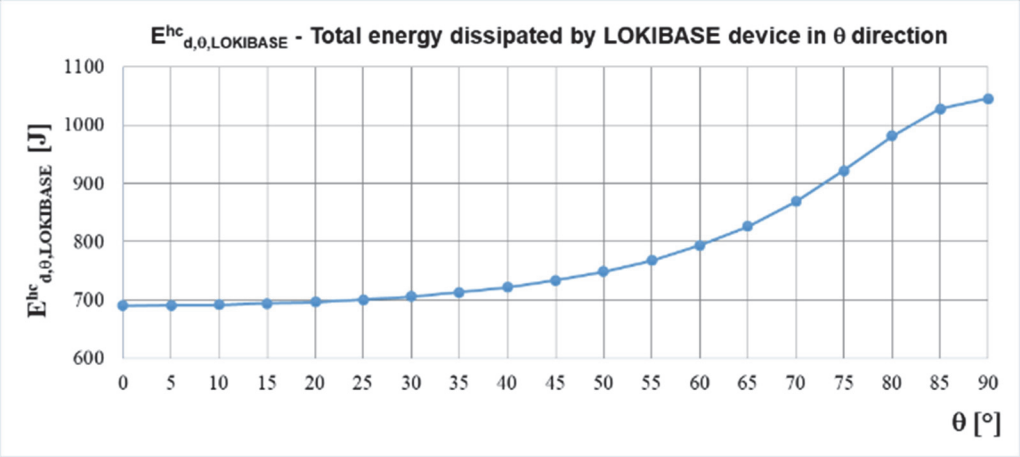


Fig. 10 Total energy dissipated by LOKIBASE device in θ direction.

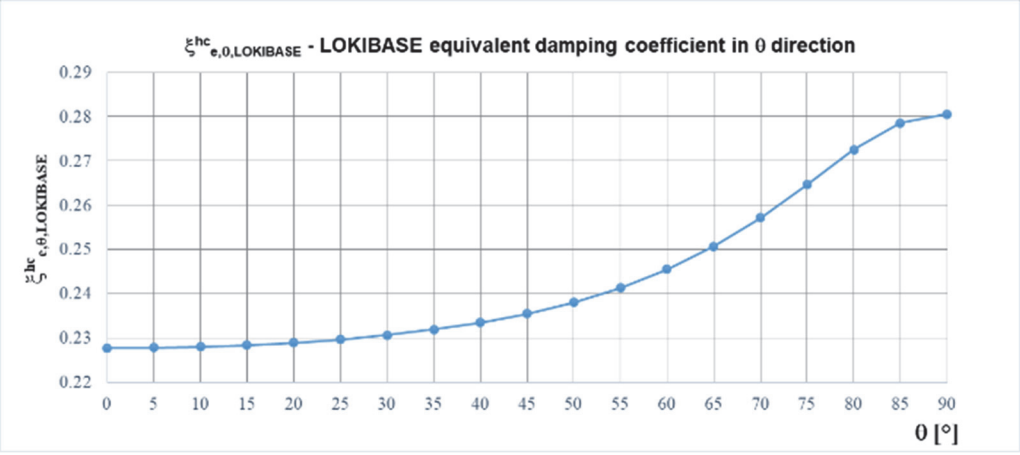


Fig. 11 LOKIBASE equivalent damping coefficient in θ direction.

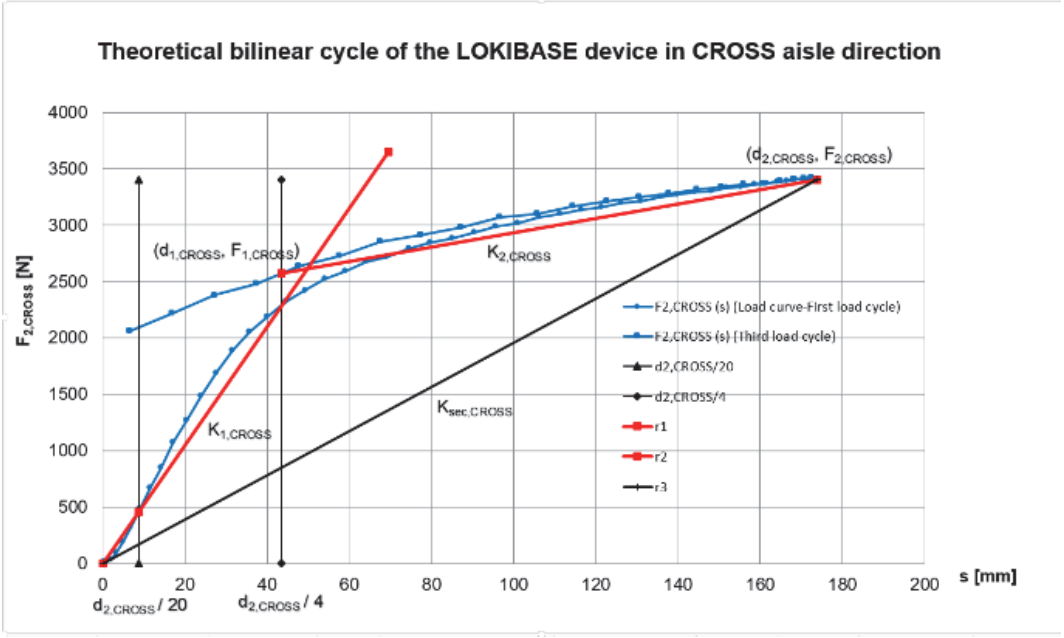


Fig. 12 Theoretical elastic behavior of the LOKIBASE in CROSS-aisle direction.

Note: In Fig. 12, ^{hc} superscript and $_{LOKIBASE}$ subscript are not reported.

3.3 Theoretical Bilinear Cycles of the Optimized LOKIBASE Device (with Holed Cylindrical Beam Damper)

In Fig. 12, the theoretical elastic behavior of the optimized LOKIBASE device in CROSS-aisle direction is shown.

In Table 10, the data of the theoretical bilinear cycle of the optimized LOKIBASE device in CROSS-aisle direction are summarized.

In Fig. 13, the theoretical elastic behavior of the optimized LOKIBASE device in DOWN-aisle direction is shown.

In Table 11, the data of the theoretical bilinear cycle of the optimized LOKIBASE device in DOWN-aisle direction are summarized.

Table 10 Theoretical bilinear cycle of the LOKIBASE device in CROSS-aisle direction.

Parameter	Value	Note
$d^{hc}_{el,CROSS,LOKIBASE}$ (mm)	8.7	Displacement in the first branch of the load test where the behavior of LOKIBASE device is linear. A value $d_{2,CROSS}/20$ is taken
$F^{hc}_{el,CROSS,LOKIBASE}$ (N)	456	Force for $d^{hc}_{el,CROSS,LOKIBASE}$ displacement in the first branch of the load test where the behavior of LOKIBASE device is linear
$d^{hc}_{1,CROSS,LOKIBASE}$ (mm)	49.8	Displacement of LOKIBASE device at the intersection point of the r_1 and r_2 straight lines
$F^{hc}_{1,CROSS,LOKIBASE}$ (N)	2,614	Force on LOKIBASE device at the intersection point of the r_1 and r_2 straight lines
$d^{hc}_{2,CROSS,LOKIBASE}$ (mm)	174	Maximum design displacement of the LOKIBASE device at the Limit state for collapse prevention SLC
$F^{hc}_{2,CROSS,LOKIBASE}$ (N)	3,408	Force on LOKIBASE device for the $d^{hc}_{2,CROSS,LOKIBASE}$ displacement, in the third cycle of the load test
$K^{hc}_{1,CROSS,LOKIBASE}$ (N/mm)	52.5	Elastic stiffness (first branch) of LOKIBASE device
$K^{hc}_{2,CROSS,LOKIBASE}$ (N/mm)	6.4	Post-elastic stiffness (second branch) of LOKIBASE device
$K^{hc}_{sec,CROSS,LOKIBASE}$ (N/mm)	19.6	Secant stiffness of LOKIBASE device
μ_{LOKI}	0.15%	Friction coefficient of LOKI devices
$E_{d,2\ LOKI}$ (J)	114	Energy dissipated by two LOKI devices
$E^{hc}_{d,CROSS,damper}$ (J)	931	Energy dissipated by the cylindrical beam damper
$E^{hc}_{d,CROSS,LOKIBASE}$ (J)	1,045	Energy dissipated by LOKIBASE device
$\xi^{hc}_{e,CROSS,LOKIBASE}$	0.28	LOKIBASE device equivalent viscous damping coefficient

Note: ^{hc} Holed cylindrical beam damper.

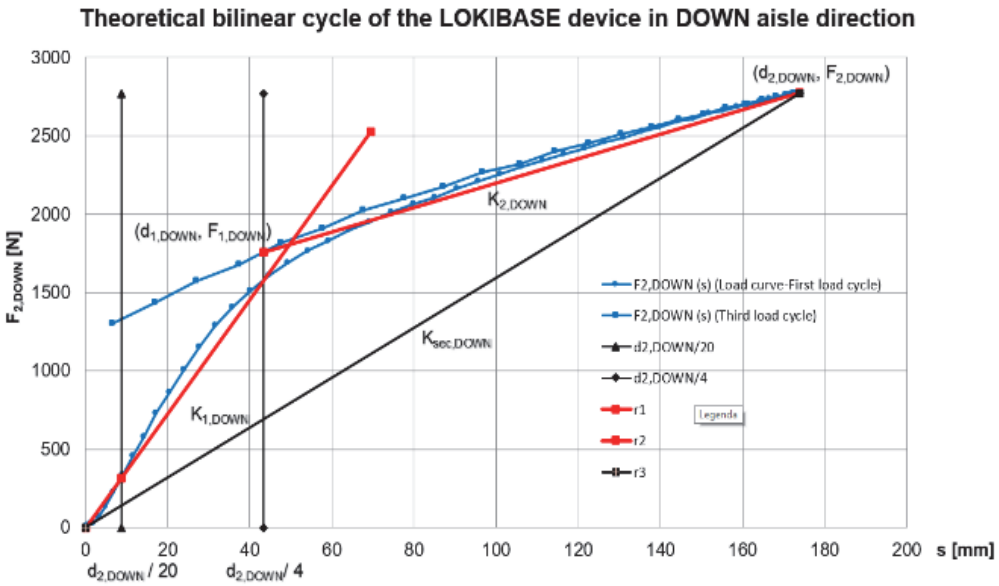


Fig. 13 Theoretical elastic behavior of the LOKIBASE in DOWN-aisle direction.

Note: In Fig. 13, ^{hc} superscript and $_{LOKIBASE}$ subscript are not reported

Table 11 Theoretical bilinear cycle of the LOKIBASE device in DOWN-aisle direction.

Parameter	Value	Note
$d^{hc}_{el,DOWN,LOKIBASE}$ (mm)	8.7	Displacement in the first branch of the load test where the behavior of LOKIBASE device is linear. A value $d_{2,DOWN}/20$ is taken
$F^{hc}_{el,DOWN,LOKIBASE}$ (N)	315	Force for $d^{hc}_{el,DOWN,LOKIBASE}$ displacement in the first branch of the load test where the behavior of LOKIBASE device is linear
$d^{hc}_{1,DOWN,LOKIBASE}$ (mm)	49.8	Displacement of LOKIBASE device at the intersection point of the r_1 and r_2 straight lines
$F^{hc}_{1,DOWN,LOKIBASE}$ (N)	1,807	Force on LOKIBASE device at the intersection point of the r_1 and r_2 straight lines
$d^{hc}_{2,DOWN,LOKIBASE}$ (mm)	174	Maximum design displacement of the LOKIBASE device at the Limit state for collapse prevention SLC
$F^{hc}_{2,DOWN,LOKIBASE}$ (N)	2,772	Force on LOKIBASE device for the $d^{hc}_{2,DOWN,LOKIBASE}$ displacement, in the third cycle of the load test
$K^{hc}_{1,DOWN,LOKIBASE}$ (N/mm)	36.3	Elastic stiffness (first branch) of LOKIBASE device
$K^{hc}_{2,DOWN,LOKIBASE}$ (N/mm)	7.8	Post-elastic stiffness (second branch) of LOKIBASE device
$K^{hc}_{sec,DOWN,LOKIBASE}$ (N/mm)	15.9	Secant stiffness of LOKIBASE device
μ_{LOKI}	0.15%	Friction coefficient of LOKI devices
$E_{d,2\ LOKI}$ (J)	114	Energy dissipated by two LOKI devices
$E^{hc}_{d,DOWN,damper}$ (J)	576	Energy dissipated by the cylindrical beam damper
$E^{hc}_{d,DOWN,LOKIBASE}$ (J)	690	Energy dissipated by LOKIBASE device
$\xi^{hc}_{e,DOWN,LOKIBASE}$	0.23	LOKIBASE device equivalent viscous damping coefficient

Note ^{hc} Holed cylindrical beam damper.

4. Conclusions

In Section 3.2 it is shown that, in the down-aisle direction a reduction in the stiffness value of the LOKI devices (from k = 6 N/mm to k = 5 N/mm) and an optimization of the shape of the cylindrical beam damper (18 mm diameter bar, holed with a 6 mm diameter hole with the axis in the direction of the down-aisle direction placed at the industrial floor level) allow reducing the horizontal force on the standard LOKIBASE device from $F^{c}_{2,LOKIBASE}$ = 3,484 N (LOKI devices with k = 6 N/mm and LOKIBASE beam damper with circular cross section diam. 16 mm – as given in Eq. (2), Chapter 2) to $F^{hc}_{2,DOWN,LOKIBASE}$ = 2,772 N (optimized LOKIBASE device, Table 11). The ratio of the $F^{hc}_{2,DOWN,LOKIBASE}$ to the $F^{c}_{2,LOKIBASE}$ is 0.79 as given in Eq. (3) (a reduction of 21% in the value of the $F^{c}_{2,LOKIBASE}$). In the same direction, neglecting the vertical constraint contribution due to the horizontal strut at the bottom of the upright frame in the cylindrical beam damper flexural bending (theoretical configuration only), the theoretical reduction is 27.0% (see Eq. (4)).

In the same section, it is shown that, in the cross-aisle direction a reduction in the stiffness value of the LOKI devices (from k = 6 N/mm to k = 5 N/mm) and an optimization of the shape of the cylindrical beam damper (18 mm diameter bar, holed with a 6 mm diameter hole with the axis in the direction of the down-aisle direction placed at the industrial floor level) allow rising the equivalent viscous damping coefficient $\xi_{e,CROSS,LOKIBASE}$ from 23.5% (standard LOKI device, Table 1) to 28% (optimized LOKIBASE device, Table 10). In the cross-aisle direction, the LOKIBASE device displacement value is reduced about of 7.0%. Table 12 summarized the percent reductions in the horizontal force acting on the optimized LOKIBASE device (code C) with reference to the standard configuration (code B) and to the theoretical configuration (code A) in the down-aisle direction.

Table 12 Percent reductions in the horizontal force acting on the optimized LOKIBASE device.

Code	Force acting on two LOKI devices at d_2 = 174 mm (N)		Force acting on LOKIBASE cylindrical beam damper in DOWN-aisle direction at d_2 =174 mm (N)			Total force acting on LOKIBASE device in DOWN-aisle direction at d_2 =174 mm (N)	Percent reduction (with reference to Code A) (%)	Percent reduction (with reference to Code B) (%)
	Standard LOKI	Optimized LOKI	Standard beam damper		Optimized beam damper			
	LOKI device stiffness k = 6 N/mm	LOKI device stiffness k = 5 N/mm	Without second order effects	With second order effects	With second order effects			
A	2,088		1,716			3,804		
B	2,088			1,396		3,484		
C		1,740			1,032	2,772	27.0	21.0
Note								
	LOKIBASE device configurations							
Code A	k = 6 N/mm; cylindrical beam damper with circular cross-section and without second order effects (Theoretical configuration only)							
Code B	k = 6 N/mm; cylindrical beam damper with circular cross-section and with second order effects (Standard configuration, Chapter 2)							
Code C	k = 5 N/mm; optimize cylindrical beam damper with second order effects (Optimized configuration, Chapter 3)							

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Research on the Development Pattern Optimization of China's Central Plains Urban Agglomeration from the Perspective of Historical and Cultural Resources

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Abstract: China is one of the countries with the longest history in the world. The protection and development of historical and cultural resources is an issue worthy of attention in the fields of economic geography and urban-rural planning at the present stage. This study takes the Zhongyuan Urban Agglomeration, which is rich in historical and cultural heritage, as a specific case, analyzes the characteristics of the spatial-temporal distribution pattern of its historical and cultural resources. The results show that the distribution structure of historical and cultural element resources within the Zhongyuan Urban Agglomeration presents significant regional agglomeration and combination characteristics. In response to the analysis results, the study formulates an optimization strategy for the regional development pattern supported by the protection and development of historical and cultural resources, and initially proposes a matching spatial development pattern plan and policy recommendations for coordinated development.

Key words: Historical and cultural resources, regional development pattern, point pattern analysis, central plains urban agglomeration.

1. Introduction[1]

China has a long history and splendid civilization, and the Central Plains region with Henan Province as the main body is the birthplace of the Chinese nation and Chinese civilization. Historically, from the Xia Dynasty to the Song Dynasty, the Central Plains has always been the political, economic and cultural center of China. More than 20 dynasties have established or moved their capitals here. Among the eight ancient capitals of China, Luoyang, Kaifeng, Anyang and Zhengzhou are four ancient cities in the Central Plains. It is the area with the largest number of dynasties, the longest history of capital establishment and the largest number of ancient capitals in China [1].

This study takes the Central Plains Urban Agglomeration approved by the State Council in 2016 as the research scope (Fig. 1), involving 5 provinces and 30 cities [2]. The Central Plains Urban Agglomeration, as the urban concentration area with the richest historical and cultural resources in China, is still lacking development work for its own historical and cultural value, and there are many problems to be solved. In recent years, the historical and cultural resources within the Central Plains Urban Agglomeration have been continuously destroyed, and the existing high-quality resources are decreasing. It is urgent to intervene and protect through planning.

Therefore, the following questions are raised: (1) What are the temporal and spatial distribution characteristics of historical and cultural resources in the Central Plains Urban Agglomeration? (2) How to give full play to the value of historical and cultural resources in regional development? At present, there is a relative lack of relevant research on this topic in the academic community, which has not attracted enough attention.

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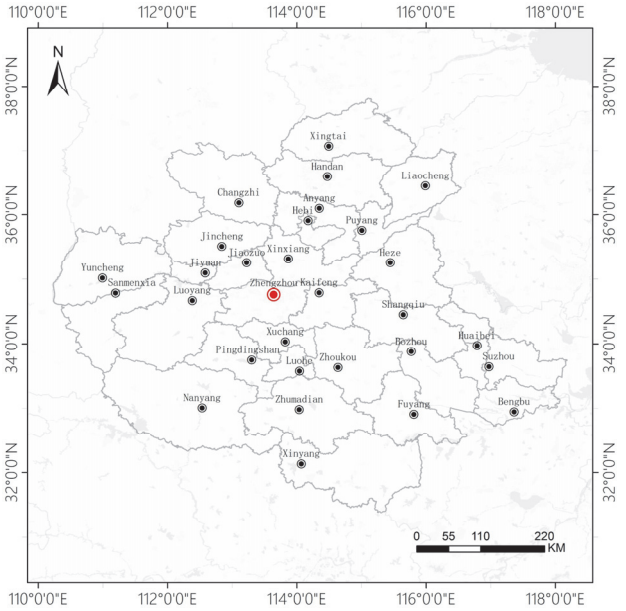

Fig. 1 Study area: the Central Plains Urban Agglomeration.

The strategic planning at the national and regional levels has put forward new requirements for the development and protection of the historical resources of the Central Plains Urban Agglomeration. Therefore, it is urgent and necessary to study the overall development pattern of the Central Plains Urban Agglomeration from the perspective of historical and cultural resources.

2. Data Sources and Research Methods

2.1 Data Sources

The key data source is the POI (point of interest) of the historical and cultural resources of 30 prefecture level cities within the Central Plains Urban Agglomeration. The auxiliary analytical data mainly include: (1) The permanent population and GDP (gross domestic product) data of prefecture level cities; (2) City search index information flow data; (3) Traffic network and passenger transport frequency data of high-speed rail; (4) NDVI (normalized difference vegetation index), terrain (DEM: Digital Elevation Model) and water system data, land use data (ESA (European Space Agency) worldcover), soil texture types and precipitation related data.

2.2 Methodology

2.2.1 Research Concept

The development of historical and cultural resources is directly and indirectly influenced by many factors. Through summarizing relevant literature [3-5], this study extracted four key elements: urban system, social economy, regional transportation, and ecological pattern, and conducted a comprehensive analysis of the development of the Central Plains Urban Agglomeration under macro conditions and higher-level planning background.

2.2.2 Research Methods

(1) L-Function Method

A commonly used point pattern analysis method introduces spatial scale and generates statistical data for spatial clustering based on a certain search range radius. In this study, the L-function is introduced to determine the spatial distance of regional historical and cultural resource points in the maximum aggregation state, which is the characteristic scale of the spatial pattern of historical and cultural resources. The calculation formula is as follows:

$$L(d) = \sqrt{\frac{A\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N} k(i,j)}{\pi N(N-1)}} \tag{1}$$

In the formula, A is the area of the region, N is the number of points, d is the distance threshold, and $k(i,j)$ is the weight. When the distance between i and j is less than or equal to d, the given weight is 1, and when the distance is greater than d, the weight is 0.

$$f(x,y) = \frac{1}{nh^2}\sum_{i=1}^{n} w_j k(\frac{d_i}{h}) \tag{2}$$

In this expression, $f(x, y)$ is the density estimate of the spatial position at (x, y), h is the bandwidth or smoothing parameter, which can be set according to the scale $L(d)$ mentioned above, and d_i is the distance from the (x, y) position to the observation position; N is the observation value, $k(x)$ is the Gaussian kernel function, and w_j is the weight of level j.

(2) Geographic Network Model

The study uses geographic network to analyze the spatial combination of different types of historical and cultural resources, and uses correlation matrix to express it. The vertices in the network graph represent the center points of different types of historical and cultural resources, while the edges between the vertices represent the combination of different types of historical and cultural resources. The vertex set V of graph $G=(V,E)$ is an n-order correlation matrix, and the edge E is a constraint function.

$$G(V_{ij}) = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1m} \\ v_{21} & v_{22} & \cdots & v_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ v_{n1} & v_{n2} & \cdots & v_{nm} \end{bmatrix} \tag{3}$$

$$G_h(E_{ij}) = \begin{cases} 0 & (s > h) \\ \sum_{i=1}^{n} E_{ij} & (s \le h) \end{cases} \tag{4}$$

V_{ij} is the relationship between v_i and v_j, indicating the type of historical and cultural resources; E_{ij} is the actual number of interconnection edges between i nodes directly connected to j nodes, s is the distance between v_i and v_j, and h is the distance threshold.

3. Analysis of Spatial Pattern of Historical and Cultural Resources

3.1 Spatial Distribution Characteristics of Cultural Relics Protection Units

3.1.1 Overall Spatial Distribution Pattern

According to the weighted analysis of the core density of historical and cultural resources (Fig. 2), the spatial distribution pattern of cultural protection units in the Central Plains Urban Agglomeration is obtained. It is found that it has an obvious continuous accumulation trend, showing a "corridor multi-core" structure of "high in the West and low in the East, high in the North and low in the South". The "cross" shaped gathering corridor is composed of a vertical corridor from Liaocheng to Nanyang and a horizontal axis from Bozhou to Luoyang; The "1+3+N" agglomeration centers are the regional agglomeration centers formed in the northwest of the region, the three main local agglomeration centers of Zhengzhou-Kaifeng-Luoyang, Changzhi-Jincheng, Xingtai-Handan-Anyang, and several other general local agglomeration centers such as Yuncheng.

In order to determine the analysis scale of the regional spatial pattern, the Ripley's K function was used to analyze the characteristic scale of the spatial distribution pattern of the national key cultural relics protection units in the Central Plains Urban Agglomeration. It can be seen from Table 1 that the ObservedK curve of cultural protection units within 270 km is higher than the ExpectedK curve (high confidence interval), which explains the clustering distribution of cultural protection units. With the increase of distance, the ObservedK curve first gradually moves away from the ExpectedK curve, and then gradually moves closer. The DiffK enters the steady state at 130 km and reaches the maximum value, at which time the aggregation degree of spatial distribution reaches the maximum value. Therefore, 130 km is selected as the analysis scale of regional spatial pattern.

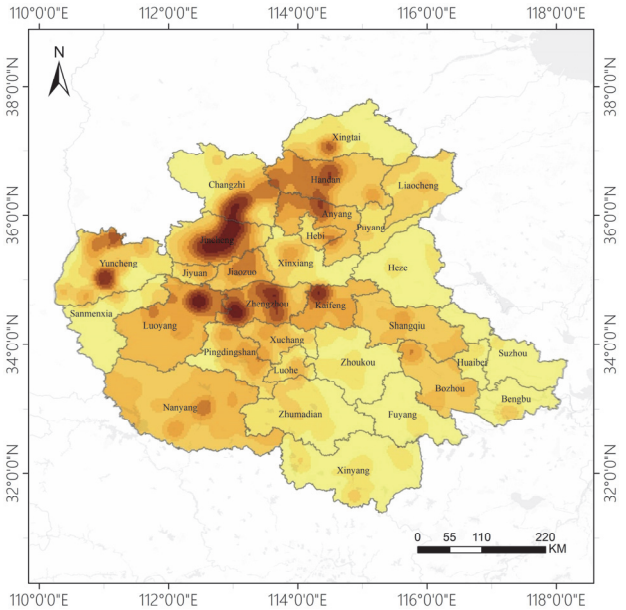

Fig. 2 Weighted density of historical and cultural resources.

Table 1 Value distribution of K-function related indicators.

ExpectedK (Unit: m)	ObservedK (Unit: m)	DiffK	LwConfEnv	HiConfEnv
101,000	140,511.6087	39,511.60873	92,465.77	95,509.41209
108,000	147,962.8297	39,962.8297	98,244.83037	101,567.8093
115,000	155,782.8747	40,782.8747	104,018.7387	107,698.1283
122,000	163,455.6772	41,455.67721	109,655.8373	113,746.2456
129,000	170,999.8268	41,999.82679	115,251.1781	119,594.3481
136,000	177,943.3985	41,943.39845	120,719.8595	125,453.6088
143,000	184,964.5703	41,964.5703	126,118.4569	131,445.9901
150,000	191,704.6239	41,704.62389	131,478.0376	137,096.9764

Taking 130 km as the threshold, the geographical network model of historical and cultural resources was established, and the connection structure based on spatial proximity was found. It was found that the connection in the northwest of the region was dense, and the connection to Nanyang, Zhumadian, Shangqiu, Huaibei, Liaocheng and other places was sparse linear.

In order to further simplify the network structure, the peak point extraction method on the gradient weighted kernel density map is used to screen the main cultural protection units located in the high value center of the weighted kernel density. Based on the selected cultural spots in the "peak area", the geographic network skeleton of cultural relics protection unit points was extracted with 130 km as the threshold; It is found that there are three main structural types, namely, the network area, the corridor connection area and the blank area. Then, the spatial connection structure in local areas was further explored at 65 km and 50 km respectively, and it was found in Zhengzhou-Kaifeng-Luoyang-Jincheng, Pingdingshan-Luohe-Zhoukou, Handan-Xingtai, Xinxiang-Hebi-Anyang-Puyang; Liaocheng, Sanmenxia, Changzhi and other regions have strong local ties.

3.1.2 Spatial Distribution Characteristics of Different Types and Historical Periods

A total of 751 cultural relics protection units in six batches were counted by type and age. In terms of types, there are six categories, including ancient buildings, ancient sites, ancient tombs, representative buildings of modern and contemporary important historical sites, cave temples and stone carvings, and others, of which ancient buildings and ancient sites are the main ones; In terms of time, it can be divided into seven categories: Pre-Qin, Qin and Han Dynasties, Wei Jin Southern and Northern Dynasties, Sui Tang and the Five Dynasties, Song and Yuan Dynasties, Ming and Qing Dynasties, and modern times, with the cultural protection units in Pre-Qin, Song and Yuan Dynasties, and Ming and Qing Dynasties as the main ones.

Using the peak point extraction method, the high value centers of nuclear density of the main types of cultural relics protection units and the main age cultural relics protection units were extracted (Fig. 3). There are 136 high-value centers by type and 133 high-value centers by age. The characteristic scale of the spatial distribution pattern of the national key cultural relics protection units in the Central Plains Urban Agglomeration is analyzed. The result is 80 km. Taking this as the threshold, the geographical network model of the peak point is established to find the contact structure based on spatial proximity by type and age.

Using a geographic network analysis method with a threshold of 80 km, different types of cultural resource spatial connection matrices and spatial combination relationships were obtained. In terms of overall connection strength, ancient architecture has formed the closest connection with other types of historical and cultural resources, especially the connection between ancient architecture and grotto temples. This is related to the large number of stone carvings in ancient architecture

and grotto temples, as well as their widespread distribution; The connections between ancient tombs and sites are relatively limited. In terms of the spatial combination of historical and cultural resources by age, from the perspective of overall connection strength, the historical and cultural resources of the Ming and Qing dynasties, Song and Yuan dynasties, Sui Tang and the Five Dynasties formed the closest connections among them; The historical and cultural resources of modern times are relatively isolated. From a spatial perspective, the combination of cultural resources is mainly distributed in the northwest and central parts of the region.

3.2 Spatial Distribution Characteristics of Other Historical and Cultural Resources

In addition to material cultural resources, the Central Plains Urban Agglomeration also has rich intangible cultural heritage. Currently, there are 310 intangible cultural heritages which belong to 10 major categories, including traditional drama, folk art, and folk customs. Through nuclear density analysis, it was found that high-density areas are mainly concentrated in the northern part of the region, with significant agglomeration zones of Changzhi-Jincheng-Jiaozuo-Luoyang, Xingtai-Handan-Puyang-Heze, and Yuncheng (Fig. 4).

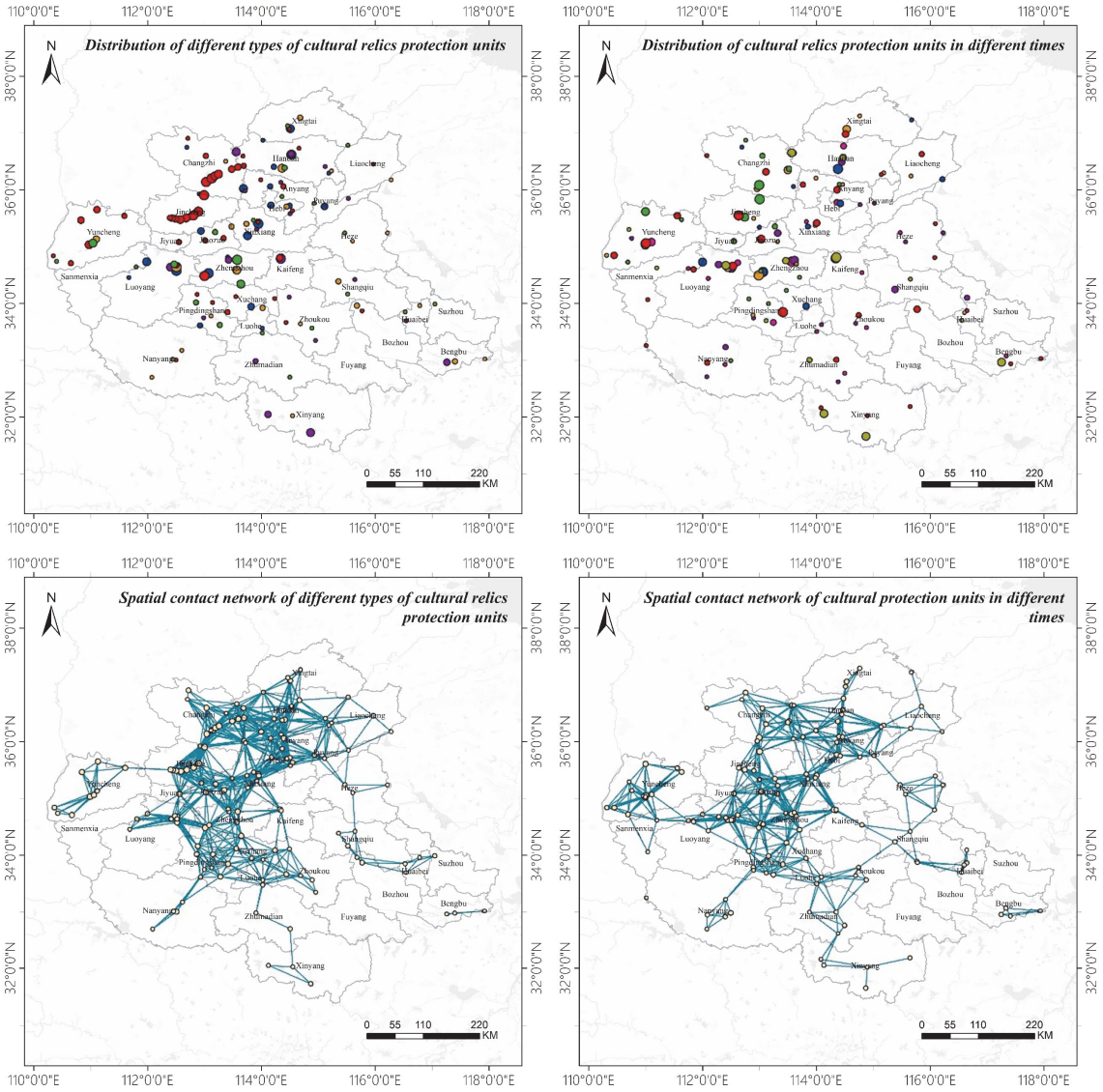

Fig. 3 Distribution of cultural relics protection units and spatial connection network.

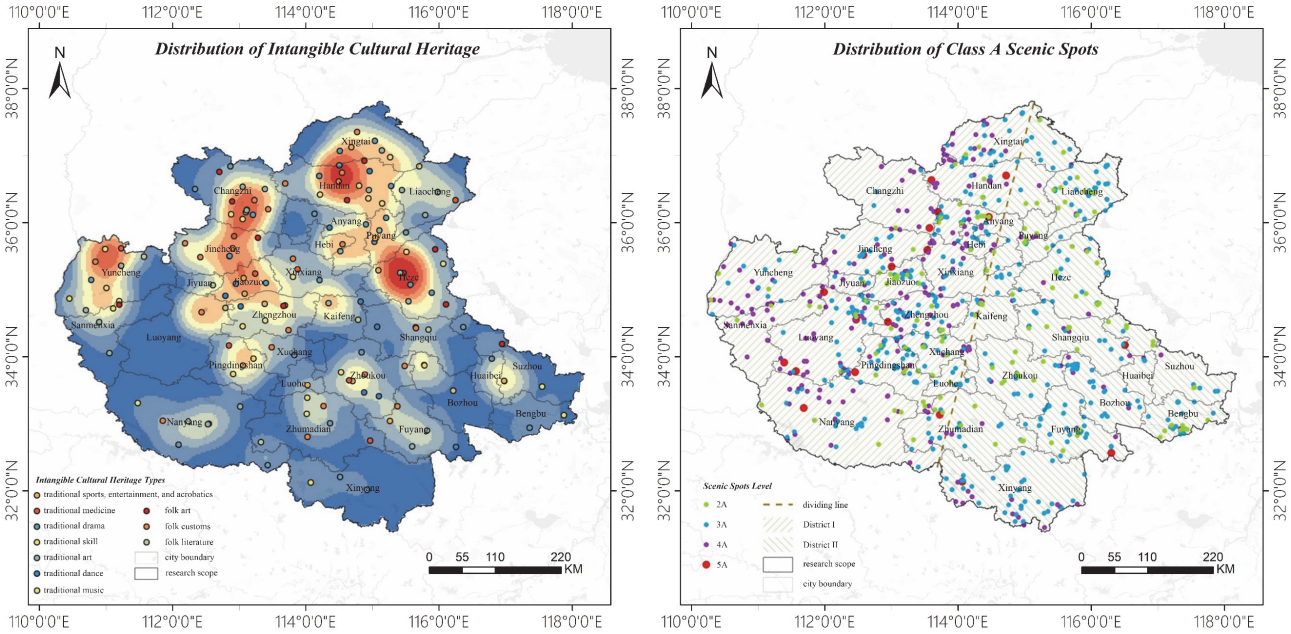

Fig. 4 Distribution of intangible cultural heritage and class A scenic spots.

After analyzing the current tourism resources, it was found that they are unevenly distributed in space from east to west. A dividing line from Xingtai in the north to Xinyang in the south divides the Central Plains urban agglomeration into two parts. To the west of the dividing line, tourism resources are abundant, covering 85% of 5A level scenic spots, 77% of 4A level scenic spots, more than half of 2A and 3A level scenic spots with 52.5% of the area. The high-density areas are mainly concentrated in the central part of the area, namely the core area of Jincheng-Jiaozuo-Zhengzhou-Luoyang-Pingdingshan, while other areas have lower density and several point like clusters. Based on this, the spatial distribution pattern of tourism resources in the Central Plains Urban Agglomeration can be divided into three levels of hotspots: (1) the core area is a first level hotspot; (2) Kaifeng, Hebi-Anyang, Liaocheng, Xingtai-Handan, Fuyang, Bozhou and Bengbu are second level hotspots; (3) the remaining areas are third level hotspots.

4. Optimization Strategies for Development Pattern of the Central Plains Urban Agglomeration

4.1 Overall Development Goal of the Region Guided by History and Culture

4.1.1 The Comprehensive Prosperity of the Historical and Cultural System

Fully leverage the advantages of historical and cultural resources in the Central Plains Urban Agglomeration, vigorously promote the excavation, integration, and utilization of related resources, and establish a sound system and system for the protection and inheritance of cultural heritage.

4.1.2 High-Quality Coordinated Development of Industrial Economy

Establish and improve the economic development network structure of "one core and five zones", with a focus on enhancing and developing historical cultural and creative industries and related industries.

4.1.3 The Transportation Network Promotes Resource Linkage

Build an intensive and compact transportation network within the region, forming a "Central Plains Urban Agglomeration Traffic Circle" throughout the entire area. Comprehensively upgrade and update intercity railways, water transportation, aviation and other facilities; fully implement the guiding ideology of "internal connectivity and external smoothness, interconnection and intercommunication".

4.1.4 Establish a Harmonious and Symbiotic Ecological Pattern and Resilient Security System

Comprehensively realize the diversified construction of ecological networks, creating an ecological barrier and collaborative system of "one axis and three areas", and promote the formation of a cultural ecological pattern of coordinated development of historical and cultural industries and ecological environment protection.

4.2 Optimization of Spatial Support System for Historical and Cultural Resources

4.2.1 Enhance Economic Synergy System

Overall, it is necessary to build an economic development network of "one core and five zones", with cities such as Zhengzhou and Kaifeng still serving as core urban areas, accelerating the development of emerging industries and modern service industries.

In the western and northern regions, such as Yuncheng-Sanmenxia, Changzhi-Jincheng, and Handan-Anyang, zones with a focus on the protection and development of historical and cultural resources should be constructed; Meanwhile, build collaborative demonstration zones in the eastern and southern regions, such as Heze-Shangqiu and Nanyang-Zhumadian, with organic coordination of functions and integrated development within and outside the region as the main functions, to undertake advanced industries at home and abroad, further synergize with historical and cultural resources, and form a cross regional industrial network [6].

4.2.2 Optimize Comprehensive Transportation System

It is necessary to coordinate the historical and cultural structure of the region and construct a multi-level transportation network system; Building an intercity railway and aviation network to achieve linkage of regional historical and cultural resources will also play an important role; And the government should also improve the collaborative governance system of transportation and promote the exchange of regional historical and cultural resources.

4.2.3 Build Ecological Protection System

It is suggested to build an ecological barrier system of "one axis and three sections". One axis is the Yellow River Ecological Corridor, adhering to the coordinated planning of upstream and downstream, main and tributary, left and right banks, and constructing ecological corridors along the Yellow River according to local conditions; The three areas, namely Taihang Mountain Ecological Protection Zone, Funiu Mountain Ecological Protection Zone, and Tongbai-Dabie Mountain Ecological Protection Zone, which is aimed to enhance the water source conservation, soil and water conservation, and ecological diversity protection functions of the ecological protection zones. The goal is to form a collaborative network pattern of cultural and ecological integration, emphasizing the combination of ecological and cultural elements, and creating a cultural and ecological pattern of harmonious coexistence between historical culture and ecological environment.

4.2.4 Improve Resilience and Safety System

At the regional level, it is necessary to strengthen the defense line of large-scale facilities, coordinate disaster warning and disposal, build a R-CAS (regional complex adaptive resilience system), implement the new concept of regional resilience security, promote the construction of a regional security network with the development of historical and cultural resources as the main line, improve the regional linkage and collaborative disaster prevention, reduction and emergency response capabilities.

At the urban level, relevant departments need to improve the layout of resilient facilities and enhance awareness of cultural heritage protection. At the same time, it is essential to optimize the networked connection and coordination of the facility system, promote the networked integration of rainwater regulation and storage facilities, integrate ecological blue-green spaces, cultural exhibition spaces, and disaster resilience spaces.

5. Conclusion and Discussion

In response to the spatial and temporal distribution characteristics of historical and cultural resources, as well as their value and role in regional development, this article takes the Central Plains Urban Agglomeration as an example for a certain degree of research and exploration, and proposes optimization strategies for the relevant spatial support system. In urban and rural areas with abundant historical and cultural resources, the following points should also be noted in actual planning and construction work: (1) Strengthening the top-level design and functional integration of cultural management; (2) Accelerating the pace of integrated development of cultural tourism; (3) Protecting historical and cultural resources comprehensively and digitally; (4) Developing industrial clusters based on the convergence of historical and cultural resources.

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A Study on Life Elements Observed in Small Residential Areas in Tokyo—Survey on the Quantity and Quality of Life Elements in the Roadside Space Detached Residential Areas in Bunkyo Ward, Tokyo

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Abstract: High-rise housing is being built in increasingly densely populated urban residential areas in Tokyo, Japan. On the other hand, detached houses are built on small, subdivided sites. In urban residential areas where detached houses are lined up, many elements related to daily life are located near roadside space and spill out onto the road. This is a distinctive modern urban residential landscape. The purpose of this study is to get closer to the reality of urban residential life. For that, we will consider the characteristics and roles of elements related to daily life that can be observed in many areas around roadside space in an urban residential area lined with detached houses, in urban living environments. This study focuses on the detached residential area of Bunkyo Ward. A field survey will be conducted to investigate the amount of elements related to daily life that can be observed from the road. In addition, we will conduct a questionnaire survey of residents in the survey area regarding their use of and awareness of the roadside space. Finally, we will investigate the relationship between lifestyle factors and urban residential life from both quantitative and qualitative perspectives.

Key words: Life elements, small site, roadside space, city life, lifestyle consciousness.

1. Research Objective

1.1 Research Background/Motivation

Contrary to the recent trend of an aging population, declining birthrates, and declining population, urban residential density is increasing in Tokyo, Japan. The urban residential landscape consisting of detached houses and apartment complexes in the central urban areas of the metropolitan area and business core cities is rich in diversity. In particular, the way in which the roadside space of each house is used in detached residential areas allows us to observe and demonstrate the characteristics of urban living. Manifestations of urban dwellers' lives form part of the urban residential landscape.

Cities have various distinctive areas such as commercial, historical, industrial and residential areas. Each region needs a landscape that is appropriate for it. In Japan, the Landscape Act was established in 2004. Article 1 of the Landscape Act[1] aims to "improve people's lives and promote the healthy development of local communities." To create a landscape suitable for urban residential areas, we thought it would also be important to focus on the manifestations of urban dwellers' lives that can be observed in the roadside space.

In 2020, the Pedestrian Accessibility Improvement Road System (Hokomichi System) was established as part of a partial amendment to the Road Act. The space

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[1] Landscape Act, Article 1: The purpose of this Act is to promote the formation of good landscapes in Japan's cities, rural areas, and other areas by formulating landscape plans and taking other measures comprehensively, thereby aiming to create a beautiful and dignified nation, create a rich and fulfilling living environment, and realize unique and vibrant local communities, thereby contributing to the improvement of people's lives and the healthy development of the national economy and local communities.

around the roads will further revitalize the city and increase the attractiveness of the area through sustainable urban development. The practice and research on road utilization conducted by Professor Izumiyama [1] and his colleagues focuses on central commercial areas such as Kanda, Ikebukuro, Kashiwa, and Utsunomiya. In the central commercial district, efforts are being made to create new lively spaces around roads. However, there has been little consideration given to the roads surrounding residential areas.

This study focuses on the manifestations of life in diverse urban residential areas. And, we explored ways to arrange the roadside space of each house that would be appropriate for the residential area, and we also thought that this would contribute to improving the unique appeal of the detached housing area.

1.2 Research Purpose

This study focuses on the elements related to daily life in the roadside space of detached houses in the city, focusing on the detached houses in Bunkyo-ku, Tokyo, Japan.

In urban residential areas where many houses are built on small sites, we conduct a field survey to investigate the quantity of "elements related to the lives of residents" that can be observed in the roadside space. In addition, a questionnaire survey will be conducted among residents of the survey area regarding "how people use and their awareness of roadside space." We will consider the characteristics and roles of elements related to daily life from both quantitative and qualitative perspectives, and grasp the actual state of elements related to daily life.

1.3 The Significance and Usefulness of This Study

In urban residential areas where many houses have small sites, the roadside space is located between the road and the houses. From the roadside, we can see the roadside space of the residential property. On the other hand, residents use the roadside space as part of their daily lives.

There is a wide range of research into the external spaces of detached residential areas. Among these, research on roadside space can be categorized into landscape and architectural planning fields. In the field of landscape, Professor Hayasaka and Professor Suzuki [2] investigated the types of vegetation around roadside space in urban detached housing areas and considered the relationship between vegetation and resident awareness. In addition, Professor Inoue and Professor Senda [3] investigated the types of fences around roadside space in urban detached residential areas and considered the relationship between fences and residents' awareness. These studies focus on plantings and fences along roadsides. In the field of architectural planning, Professor Kitahara and Professor Katsura [4], considered the relationship between housing and outdoor spaces. Professor Hattori [5] studied how outdoor spaces are used and evaluated. These studies consider how external spaces are used from the perspective of the relationship between buildings and external spaces. None of the studies focused on factors related to daily life.

Having a look at the survey sites for research into the outdoor spaces of detached residential areas, Professor Inoue and Professor Senda's [3] research focused on low-rise residential areas in Tokyo. The study on the role of hedges conducted by Professor Ikezoe and Professor Terasaki [6] focused on suburban residential areas in Fukuoka that have building agreements. The research on tourism resources and cityscapes conducted by Professor Kawazu and Professor Tsuboi [7] focused on residential areas in tourist destinations. The research on the relationship between residential space and gardens conducted by Professor Umezu and Professor Sakamoto [8] and the research on the shape and characteristics of outdoor spaces conducted by Professor Noguchi and Professor Adachi [9] were conducted in residential areas in cold regions. In a study conducted by Professor Taniguchi [10] on the conditions for the existence of gardens in detached houses, it was revealed that a site area of 100 m^2 or

more is required for a garden to function. However, both studies focus on outdoor spaces and gardens. The survey did not cover detached residential areas in the city center, where many properties are small.

In recent years, the construction of detached houses on small plots of land less than 100 m2 has been increasing in urban areas. In urban residential areas, the landscape of detached houses standing side by side on small sites is one of the defining features of the urban landscape. This was made clear by Professor Asami [11] in his research on living environments. Professor Kita and Professor Nakamura [12] also clarified this in their study on the characteristics of detached houses on small sites.

The roadside space is located between the road and the building, and is a space that is influenced by both the roadside and the detached houses side. This study focuses on the elements related to daily life within this context. We thought that by understanding the actual conditions of elements related to daily life in the roadside space, we could consider urban living environments from a different perspective than landscape and planning studies (Fig. 1).

1.4 Definition of Terms

The authors have conducted research on elements related to daily life in urban residential areas [13]. Looking at previous research evaluating the components of urban landscapes, Professor Funakoshi and Professor Tsumita [14] classify the spatial components of streetscapes into the following major categories: buildings, greenery, roadways, and facilities. In their study of street landscapes, Professor Nakamura and Professor Shinohara [15] classified the components of a landscape into roads, roadsides, distant views, human activities, underground areas, and factors of change. In these studies, the elements of life that urban dwellers reveal are categorized as devices and human activities. In this study, we will refer to all elements that can be judged as devices and human activities, that is, all elements related to people's urban lives, as "life elements" (Fig. 2).

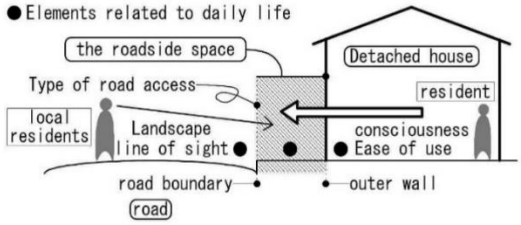

Fig. 1 Spatial characteristics in the roadside space.

The subjects of this study were detached houses in urban areas, and the survey subjects were classified by site area. Previous studies [12, 16] have shown that a small site is defined as one that is less than 70 m^2, while another defines it as one that is less than 100 m^2. Sites of less than 70 m^2 were considered "extremely small sites", and sites of 70 m^2 to 100 m^2 were considered "small sites". According to survey data from the Japan Housing Finance Agency[2], the average site area for those taking out loans for custom-built homes with land in the Tokyo metropolitan area will be 153.8 m2 in fiscal 2022 and 162.8 m2 in fiscal 2023. The average site area for those borrowing for prefabricated housing is 116.7 m^2 in fiscal year 2022 and 119.2 m^2 in fiscal year 2023. A "general site" is defined as an area between 100 m^2 and 150 m^2. In addition, the area between the road boundary line and the building exterior wall is defined as the "roadside space" (Fig. 3).

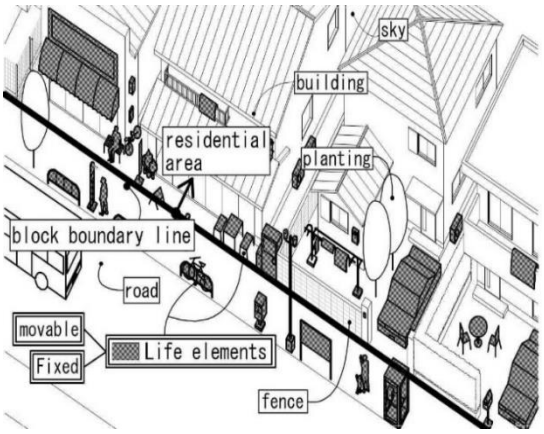

Fig. 2 Schematic diagram of life elements.

[2] Based on Flat 35 loan application data held by the Japan Housing Finance Agency (formerly the Japan Housing Loan Corporation), we referenced data for fiscal 2023 that compiles data on Flat 35 users by loan category and prefecture.

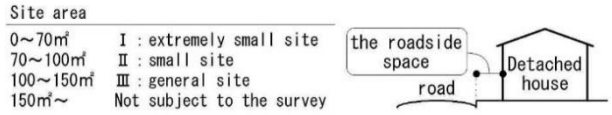

Fig. 3 Classification by site area and definition.

2. Research Plan

2.1 Research Overview

This study focuses on detached residential areas in the city center. The survey targets a detached residential area in Bunkyo Ward, located inside the Yamanote Line in central Tokyo. We refer to areas that have been introduced as detached residential areas in the city center in our previous research [13]. The survey area will be the entire Hakusan 4-chome area in Bunkyo-ku, Tokyo.

The research flow is shown (Fig. 4). A preliminary survey was conducted using map information[3] and field surveys[4] of the target area. We investigated the number of detached houses and the area of each site within the target area. Next, we conducted another field survey[5]. A quantitative survey will be conducted by investigating the type of road access in each detached residential area and the number of observable life elements. In addition, a questionnaire survey[6] will be conducted on detached houses within the target area. A qualitative survey will be conducted to investigate residents' usage and awareness of the roadside space. Next, the quantitative and qualitative survey results will be analyzed. The survey results are compared by the type of road access shapes and three types of site area. Finally, we consider the relationship between life elements and resident awareness in the roadside space in the surveyed areas.

2.2 Survey Area and Preliminary Survey

In our previous research [13], part of Hakusan 4-chome in Bunkyo Ward was introduced as a residential area of detached houses in the city center. Taking this into consideration, the entire Hakusan 4-chome area in Bunkyo Ward was selected as the survey area. As a preliminary investigation, a map of the survey area (Fig. 5) was created based on local map information and field surveys. There were 979 sites in the area, of which 735 were detached houses and 244 were other buildings. Of the 735 detached houses, 576 detached houses with a site area of 150 m^2 or less were the subjects of this study, based on survey data from the Japan Housing Finance Agency[7].

2.3 Quantitative Survey: Survey of Life Elements in the Roadside Space

Through a field survey, we observed all the life elements in the roadside space of the survey site and plotted their locations on a map. We investigated the number of all 24 types of life elements "a" to "x" (Fig. 6) that can be observed in the roadside space. In addition, we will investigate the number of life elements that spill over onto the road from the roadside space. Based on the authors' previous work [13], the survey focused on movable life elements that play a role in creating a sense of life in the urban landscape. When observing life elements, rather than simply focusing on whether they were visible or not, we tried to observe as many of the elements as possible, such as by moving our gaze to various positions and peering at elements that were difficult to see (Figs. 7 and 8).

[3] A map of the survey area was created using Vector Map Maker, which can create DXF format maps using basic map information and basic land information from the Geospatial Information Authority of Japan, national land digital information from the Ministry of Land, Infrastructure, Transport and Tourism, and elevation data from the National Geophysical Data Center, as well as ZENRIN residential maps.

[4] The preliminary field survey will be conducted from April 7th to 9th, 2025.

[5] This field survey will be conducted from April 21st to 24th, 2025.

[6] The questionnaire survey will be distributed from May 7th to 29th, 2025.

[7] Based on Flat 35 loan application data held by the Japan Housing Finance Agency (formerly the Japan Housing Loan Corporation), we referenced data for fiscal 2023 that compiles data on Flat 35 users by loan category and prefecture.

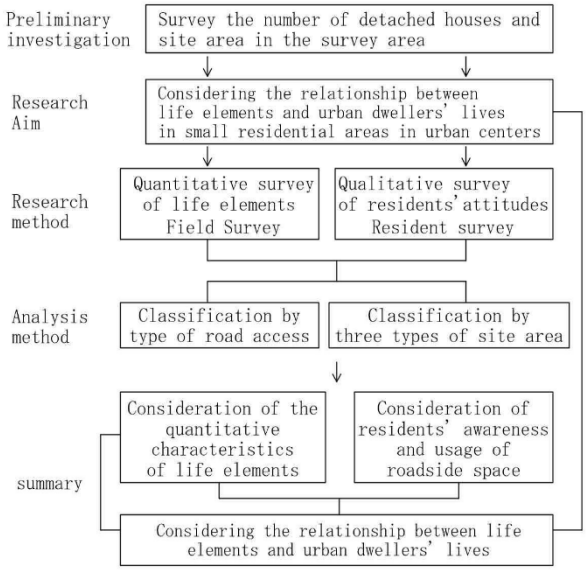

Fig. 4 Research flow.

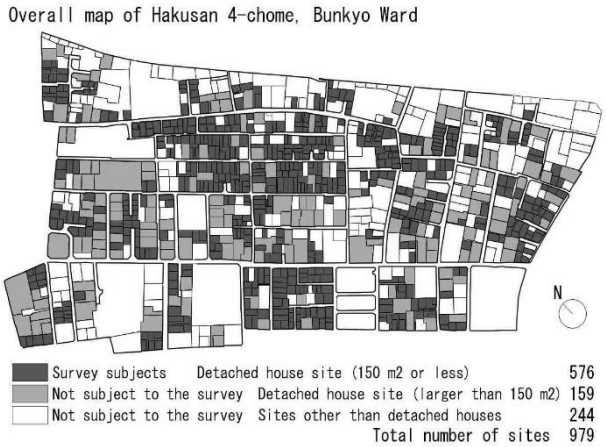

Fig. 5 Map of the survey area.

a:car b:bicycle c:flower pot d:pole e:trash box
f:local garbage box g:umbrella stand h:eliminating steps
i:storage shed j:shelf k:breeding cage l:hose m:cleaning tools
n:gardening supplies o:chair p:decoration q:stepladder
r:air pump s:miscellaneous luggage t:clothes drying rack
u:milk bottle box v:fire extinguisher w:washing machine x:mirror

Fig. 6 Types of mobile living elements observed at the survey site.

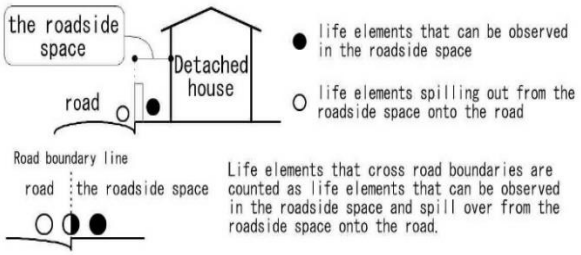

Fig. 7 Schematic diagram of observable life elements.

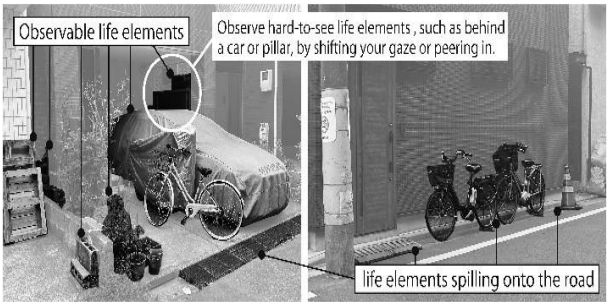

Fig. 8 Examples of observable life elements.

2.4 Qualitative Research: Questionnaire Survey of Residents

In order to understand the usage and awareness of the roadside space of residents in the survey area, a qualitative survey will be conducted using questionnaires distributed individually and collected by mail. The questionnaire items (Fig. 9) were based on previous papers by Professor Ariga and Professor Shimizu [17] on living environments. The questionnaire items were divided into three categories: (1) residents' awareness of the roadside space, (2) how to utilize the roadside space, and (3) awareness of the role of fences. Q1 to Q14 asked for responses on a five-point scale: (1) I think so, (2) I think so somewhat, (3) Neither I nor I think so, (4) I don't think so much, (5) I don't think so, and Q15[8] asked for responses on a two-point scale: (1) I have it, (5) I don't have it.

[8] For question Q15, the subjects were asked to mark whether or not their property had a fence by marking it with a circle or an X, and only answer if they thought there was a fence. There was no awareness of judging the visibility of fences.

3. Survey and Analysis: Entire Survey Area

3.1 Survey Results on Life Elements in the Roadside Space

The number and percentage of life elements that can be observed in the roadside space for all surveyed detached houses are shown below (Fig. 10). A total of 2,104 life elements were identified across all 576 detached houses surveyed. The number of life elements per dwelling unit was 3.65. The number of life elements that can be observed in the survey area is ranked in descending order—b: bicycle: 332, c: flower pot: 317, l: hose: 203, a: car: 183, m: cleaning tools: 180, s: miscellaneous luggage: 178, e: trash box: 117. Over 100 of these were identified. In addition, a scatter diagram of life elements that can be observed in the roadside space is shown (Fig. 11).

1 : residents' awareness of the roadside space
Q1 Do you think it blocks people from the outside?
Q2 Do you think it creates a beautiful cityscape?
Q3 Do you think it protects your privacy?
Q4 Do you think it enriches your relationships?
2 : how to utilize the roadside space
Q5 Do you use it as a luggage storage space?
Q6 Are you placing flower pots to create a streetscape?
Q7 Are you considering a parking space?
Q8 Do you think of it as a place to talk to people you know?
Q9 Do you think of it as a place for light exercise and children to play?
Q10 Do you think the roadside space is being utilized?
3 : awareness of the role of fences
Q11 Do you think that leaving luggage, bicycles, cars, plants, etc. in the roadside space helps prevent crime?
Q12 Do you think that luggage, bicycles, cars, plants, etc. placed in the roadside space can serve as a "substitute for a fence"?
Q13 Are you concerned about not having a fence and having your property visible from the road?
Q14 Do you think having a fence helps prevent crime?
Q15 If there is a fence, do you store items behind it?

Fig. 9 Questionnaire survey items.

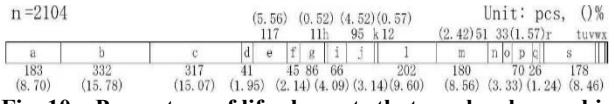

Fig. 10 Percentage of life elements that can be observed in the survey area.

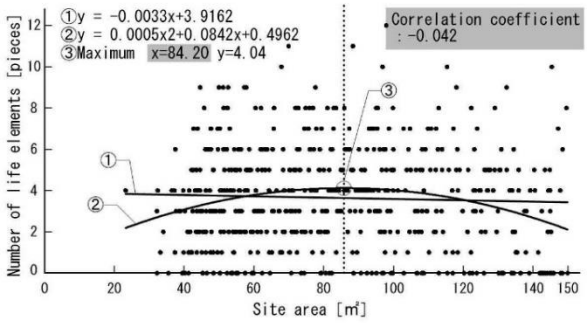

Fig. 11 Relationship diagram between the site area of the surveyed area and the life elements that can be observed.

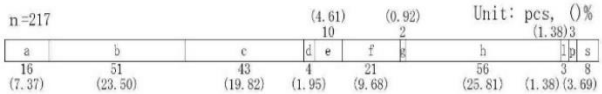

Fig. 12 Percentage of life elements spilling onto roads in the survey area.

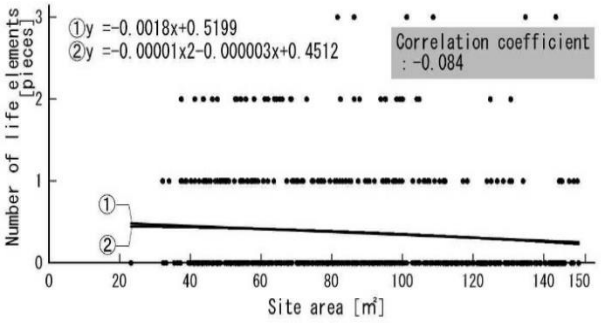

Fig. 13 Relationship diagram between the site area of the surveyed area and the life elements spilling onto the road.

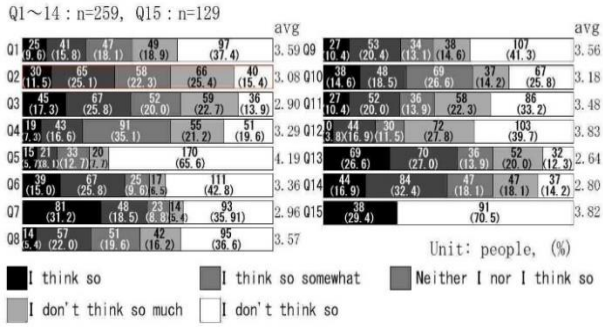

Fig. 14 Overall survey results.

3.2 Survey Results on Life Elements Spilling onto Roads

The number of life elements spilling onto the road from the roadside space of all surveyed detached houses is shown (Fig. 12). The total number of life elements spilling onto the road from the roadside space was 217. The number of life elements per dwelling unit was 0.38. The most common life elements spilling onto the road were—h: eliminating steps: 56, b: bicycles: 51, c: flowerpots: 43. Also shown is a scatter diagram of life elements spilling onto the road from the roadside space (Fig. 13).

3.3 Survey Results for the Entire Survey Area

Of the 576 questionnaires distributed, 259 were returned, for a response rate of 44.96%. The results of the overall questionnaire survey are shown above (Fig. 14).

3.4 Analysis of the Relationship between the Life Elements in the Roadside Space, and the Life Elements Spilling onto the Road and the Site Area

From Fig. 11, we focus on the shape of the linear approximation in line ① and the correlation coefficient: -0.042. The correlation between the number of life elements observable in the roadside space and the site area is extremely weak. We also noticed that the shape of the polynomial approximation in line ② is centered around the site area of 84.20 m^2.

Also, from Fig. 13, we focus on the linear approximation (line ①) and the polynomial approximation (line ②), as well as the correlation coefficient: -0.084. There appears to be an extremely weak negative correlation between the number of life elements spilling onto the road from the roadside space and the site area, but this cannot be determined from this data alone.

When site area was treated as continuous value, the correlation between site area and life elements was extremely low. In the following, Chapter 4 will analyze the relationship between the type of road access shape and life elements, and Chapter 5 will analyze the relationship between the three site area classifications and life elements.

4. Analysis by Type of Road Access Shapes

4.1 Types of Road Access Shapes

In our previous study [13], we compared three distinctive residential areas. We noted that the amount of fencing in residential areas and the amount of life elements present in the roadside space vary from neighborhood to neighborhood. Therefore, the survey areas were classified according to the type of road access shape and the amount of life elements was investigated. Based on Professor Doi's [18] research on the awareness and shape of boundaries between public and private spaces, the shape of road access is classified into eight types (Fig. 15). Regarding visibility into the site, we classified it into two categories: A to D have no visibility, and E to H have visibility. In the following, Sites ABCD with no visibility (units with fences) will be referred to as (i), and Sites EFGH with visibility (units with partial fences) will be referred to as (ii).

4.2 Survey Results for the Type of Road Access Shape in the Survey Area

On the map, the surveyed detached houses were classified by the type of road access shapes (Fig. 16), and the proportion of road access shape types was shown (Fig. 17). The types of road access shapes in the surveyed areas were (i) 28.82% and (ii) 71.18%. The survey area is characterized by the fact that more than half of the dwellings are unfenced.

4.3 Survey Results of Life Elements according to the Type of Road Access Shapes

The number of life elements by the type of road access shapes for the surveyed detached houses (Table 1) and the scatter plots of life elements by type (Figs. 18 and 19) are shown below. Comparing (i) and (ii), the number of life elements per dwelling unit is 3.61 and

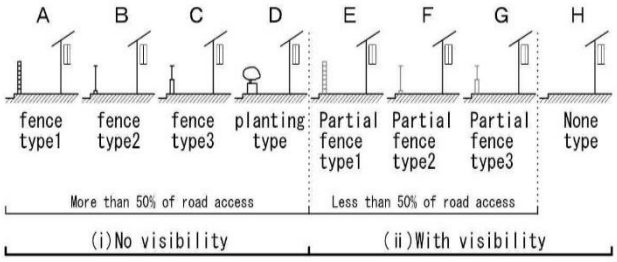

Fig. 15 Types of road access shape.

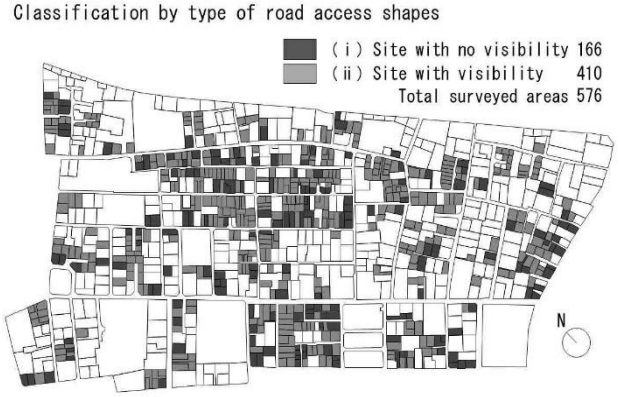

Fig. 16 Map of road access shapes in the survey.

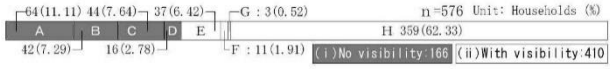

Fig. 17 Proportion of road access shapes.

3.67, respectively, with (ii) having slightly more life elements. The correlation coefficients are 0.065 for (i) and -0.083 for (ii), and the proportionality constants for the linear approximation of ① are 0.0051 for (i) and -0.0067 for (ii), which are slightly different. ② The polynomial approximation (i) is close to a straight line, but (ii) is a curve with a maximum value of ③ x = 87.41 y = 4.44. From the above, (ii) has more life elements than (i). However, the significance of both data was $p = 0.853 > 0.05$, so it cannot be said that there is a relationship between the visibility of road access shapes and the number of life elements in this study area.

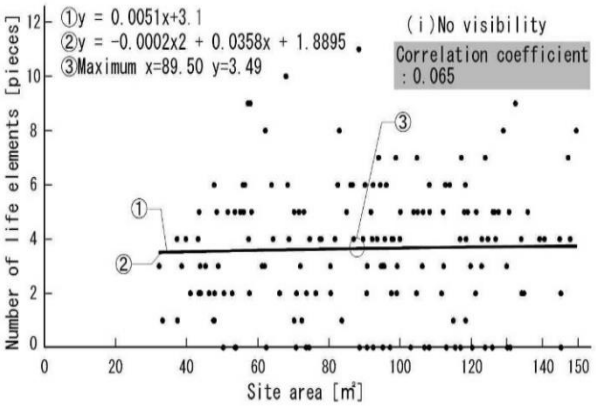

Fig. 18 A diagram showing the relationship between the site area and observable life elements on a site with no visibility.

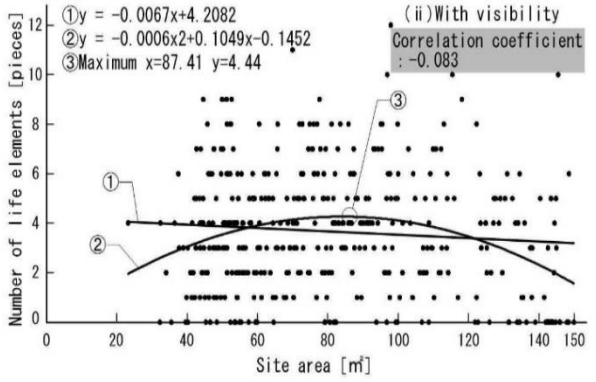

Fig. 19 A diagram showing the relationship between the site area and observable life elements for a site with visibility.

4.4 Survey Results of Life Elements Spilling onto Roads by the Type of Road Access Shapes

The number of life elements spilling onto the road by the type of road access shapes for the surveyed detached houses (Table 2) and the scatter diagrams of life elements spilling onto the road by type (Figs. 20 and 21) are shown. Comparing (i) and (ii), the number of life elements spilling onto the road per dwelling unit is 0.47 and 0.33, meaning that (i) has more life elements spilling onto the road than (ii). The correlation coefficients were -0.129 for (i) and -0.085 for (ii). The proportionality constants for the linear approximation of (i) were -0.003 for (i) and -0.0017 for (ii). The polynomial approximation of (ii) was a downward sloping trend for both (i) and (ii). Furthermore, the significance of both data was $p = 0.021 < 0.05$. From the above, it can be said that in both (i) and (ii), there is an extremely weak negative correlation between the number of life elements spilling onto the road and the site area, and that the negative correlation is stronger in (i) than in (ii).

4.5 Survey Results by the Type of Road Access Shapes

The overall survey results in Section 3.3 were simply cross-tabulated between (i) and (ii) (Fig. 22). Looking at the significance of the survey results for (i) and (ii) (Table 3), Q1: $p = 0.013$, Q3: $p = 0.002$, Q13: $p = 0.001$ were all less than 0.05, and Q14: $p = 0.058$ was close to 0.05. Furthermore, the p values for Q5, Q6, Q10, and Q11 were close to 1.0.

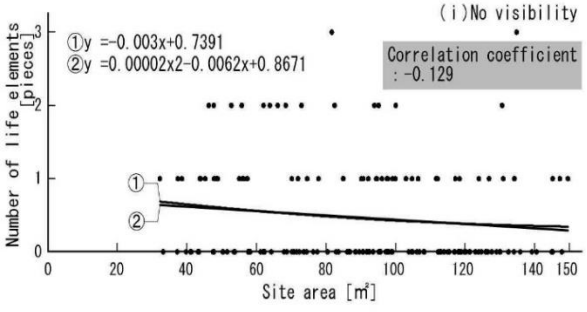

Fig. 20 Relationship diagram between the site area and the life elements spilling onto the road in a site with no visibility.

Table 1 Number of life elements by the type of road access shapes.

Road access shape	Number of life				
	Number of households	Life elements	Elements per dwelling	Deviation	*t*-test
(i): No visibility	166	600	3.61	2.44	$p = 0.856$
(ii): With visibility	410	1,504	3.67	2.47	> 0.05

Table 2 Number of life elements spilling onto roads by the type of road access shapes.

Road access shape	Number of households	An overflowing number of life elements	Number of life elements per dwelling	Deviation	*t*-test
(i): No visibility	166	77	0.47	0.70	$p = 0.021 <$ 0.05
(ii): With visibility	410	137	0.33	0.62	

Table 3 Survey results by the type of road access shapes.

	(i): No visibility				(ii): With visibility				*t*-test
	Arithmetic mean	Geometric mean	Mode	Standard deviation	Arithmetic mean	Geometric mean	Mode	Standard deviation	*p*-value
Q1	3.39	2.99	5	1.43	3.83	3.51	5	1.32	0.013
Q2	3.04	2.75	2	1.25	3.12	2.79	4	1.29	0.628
Q3	2.63	2.33	2	1.20	3.15	2.77	4	1.40	0.002
Q4	3.22	2.95	3	1.20	3.38	3.13	3	1.18	0.288
Q5	4.28	3.94	5	1.31	4.29	4.01	5	1.22	0.953
Q6	3.36	2.88	5	1.60	3.39	2.92	5	1.61	0.911
Q7	3.12	2.56	5	1.72	2.80	2.23	1	1.75	0.147
Q8	3.62	3.29	5	1.37	3.56	3.27	5	1.32	0.742
Q9	3.70	3.31	5	1.46	3.47	3.05	5	1.49	0.224
Q10	3.18	2.81	3	1.40	3.20	2.81	3.5	1.43	0.893
Q11	3.48	3.14	5	1.35	3.49	3.10	5	1.44	0.961
Q12	3.90	3.67	5	1.18	3.79	3.49	5	1.29	0.471
Q13	2.33	1.96	1	1.36	2.93	2.57	2	1.37	0.001
Q14	2.64	2.30	2	1.32	2.95	2.64	2	1.29	0.058
Q15	3.81	3.10	5	1.83					

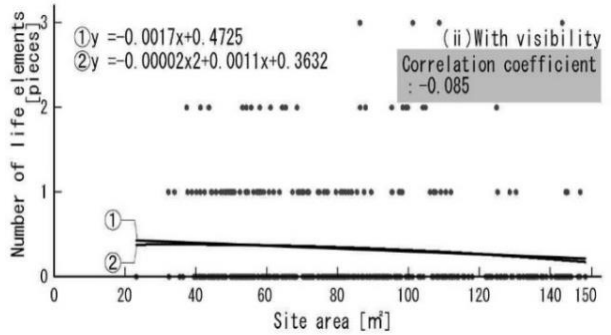

Fig. 21 Relationship diagram between the site area and the life elements spilling onto the road in a site with visibility.

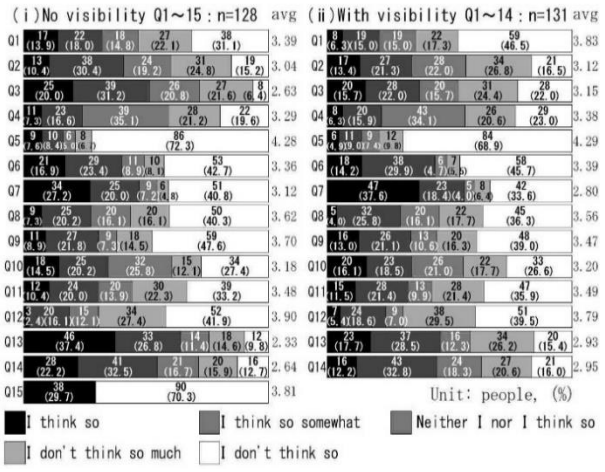

Fig. 22 Survey results by the type of road access shapes.

5. Research and Analysis: Three Types of Site Area

5.1 Three Types of Site Area Classification

Based on Section 1.4, sites with an area of less than 70 m^2 are classified as "extremely small sites", sites between 70 m^2 and 100 m^2 as "small sites", and sites between 100 m^2 and 150 m^2 as "general sites" (Fig. 23). We consider the relationship between site area and the number of life elements. Hereafter, these are referred to as (I) "extremely small sites", (II) "small site", and (III) "general site".

5.2 Survey Results of Life Elements by Three Types of Site Area

The number of life elements by three types of site area for the surveyed detached houses (Table 4) and a scatter plot of the life elements by three types (Fig. 24) are shown below. The number of life elements per dwelling unit was (II) 4.07 > (I) 3.55 > (III) 3.31. 3.1: The relationship diagram (Fig. 11) between the site area of the surveyed area and the observable life elements is divided into (I), (II), and (III) (Fig. 24). The peak of the polynomial approximation, 87.41 m^2, was in the region (II), and the significance of each data was $p = 0.011 < 0.05$.

Therefore, we considered that the comparison based on the categories (I), (II), and (III) was significant.

Fig. 23 Map of the three types of site area in the survey area.

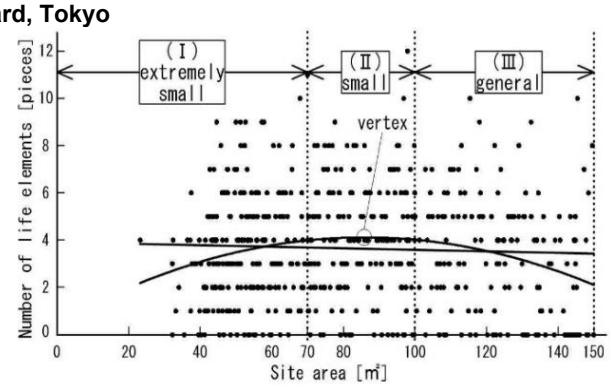

Fig. 24 Relationship diagram between the three types of site area and the life elements that can be confirmed.

5.3 Survey Results of Life Elements Spilling onto Roads by Three Types of Site Area

The number of life elements spilling onto roads for the surveyed detached houses by three types of site area (Table 5) and a scatter plot of life elements spilling onto roads by three types of site area (Fig. 25) are shown below. The number of life elements spilling onto the road per dwelling unit was (I) 0.44 > (II) 0.36 > (III) 0.31. Furthermore, the polynomial approximation is downward sloping in the ranges (I), (II), and (III). The significance of the data from the analysis of variance was $p = 0.118 > 0.05$, so it cannot be said that the classification into (I), (II), and (III) results in decreasing order of (I) > (II) > (III). However, Section 3.2 suggests that there is a strong possibility of a slight negative correlation with site area.

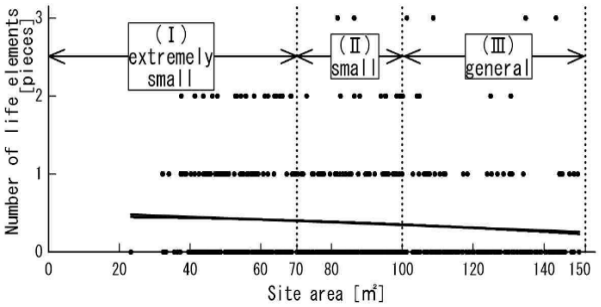

Fig. 25 Relationship diagram of life elements spilling onto roads by three types of site area.

Table 4 Number of life elements by three types of site area.

By area	Number of households	Number of life elements	Number of life elements per dwelling unit	Deviation	Analysis of variance one-way arrangement
I: extremely	223	792	3.55	2.36	
II: small	189	770	4.07	2.42	$p = 0.011 < 0.05$
III: general	164	544	3.31	2.56	

Table 5 Number of life elements spilling onto roads by three types of site area.

By area	Number of households	Number of life elements	Number of life elements per dwelling unit	Deviation	Analysis of variance one-way arrangement
I: extremely	223	99	0.44	0.66	
II: small	189	67	0.36	0.63	$p = 0.118 > 0.05$
III: general	164	51	0.31	0.67	

Table 6 Survey results by three types of site area.

	I : extremely (n I: 83)				II: small (n II: 90)				III: general (n III: 86)				Analysis of variance
	Arithmetic mean	Geometric mean	Mode	Standard deviation	Arithmetic mean	Geometric mean	Mode	Standard deviation	Arithmetic mean	Geometric mean	Mode	Standard deviation	*p*-value
Q1	3.81	3.49	5	1.31	3.51	3.16	5	1.40	3.52	3.11	5	1.45	0.293
Q2	3.31	3.03	4	1.22	3.00	2.68	2	1.30	2.94	2.63	2	1.26	0.138
Q3	3.11	2.81	2	1.27	2.94	2.62	4	1.26	2.64	2.25	2	1.41	0.064
Q4	3.46	3.20	3	1.19	3.33	3.13	4	1.07	3.12	2.82	3	1.28	0.172
Q5	4.05	3.63	5	1.46	4.37	4.10	5	1.18	4.40	4.17	5	1.11	0.159
Q6	3.65	3.25	5	1.49	3.16	2.63	5	1.69	3.34	2.89	5	1.59	0.149
Q7	2.88	2.36	5	1.69	2.63	2.07	1	1.74	3.36	2.80	5	1.71	0.020
Q8	3.54	3.20	5	1.40	3.61	3.37	5	1.21	3.62	3.26	5	1.41	0.911
Q9	3.47	3.01	5	1.55	3.45	3.07	5	1.45	3.83	3.46	5	1.41	0.173
Q10	3.27	2.94	3	1.33	3.02	2.64	2	1.42	3.27	2.85	5	1.47	0.430
Q11	3.83	3.55	5	1.26	3.34	2.98	5	1.39	3.31	2.89	5	1.47	0.028
Q12	3.91	3.65	5	1.23	3.76	3.50	5	1.22	3.87	3.59	5	1.25	0.715
Q13	2.88	2.49	2.4	1.39	2.70	2.31	2	1.39	2.35	1.98	1	1.36	0.004
Q14	2.80	2.53	5	1.20	2.91	2.56	2	1.34	2.69	2.33	2	1.39	0.558
Q15	3.67	2.92	5	1.89	3.76	3.04	5	1.85	3.88	3.20	5	1.78	0.878

5.4 Survey Results for Three Types of Site Area

The overall questionnaire survey in Section 3.3 was cross-tabulated by attributes, broken down by site area (I), (II), and (III) (Fig. 26). When examining the significance of the data from the analysis of variance of the survey results for (I), (II), and (III), the results were less than 0.05: Q7: $p = 0.020$, Q11: $p = 0.028$, and Q13: $p = 0.004$. Furthermore, the p value of Q8 was close to 1.0 (Table 6).

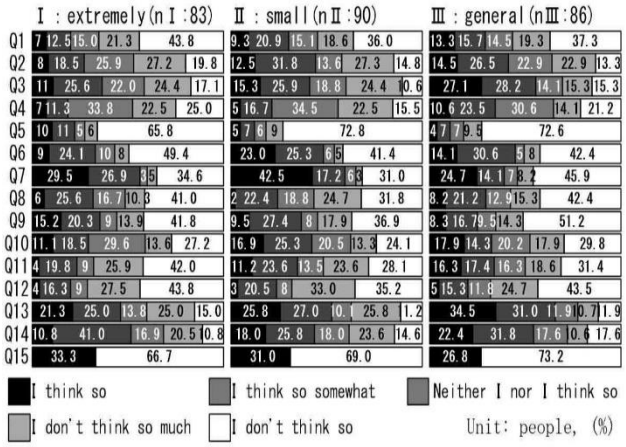

Fig. 26 Survey results by three types of site area.

6. Summary

6.1 Quantitative Characteristics of Observable Life Elements

Section 3.4 shows that there is a low correlation between the number of observable life elements and the site area. Furthermore, as shown in Section 4.3, the observable life elements are hardly affected by the road access shape. However, based on Section 5.2, if the survey site is classified as (I) "extremely small site", (II) "small site", and (III) "general site", the number of observable life elements will be (II) > (I) > (III).

6.2 Quantitative Characteristics of Life Elements Spilling onto Roads

From Sections 4.4 and 5.3, the amount of life elements spilling onto the road is influenced by the type of road access shapes and has a slight negative correlation with the site area. The larger the site area, the fewer the number of life elements that spill onto the road. When the roadside space is not visible (i), there are more life elements spilling onto the road than when the roadside space is visible (ii), and the negative correlation is stronger.

6.3 Residents' Awareness of and Use of Roadside Space

Regarding Q3 "Do you think it protects your privacy?" from Section 4.4, people are aware that privacy is better protected when road access shapes (i) are not visible. From Section 5.4, when looking at the three types of sites, $p = 0.064$. The average values are (III) > (II) > (I). The larger the site area, the more likely people are to feel that their privacy is protected. Regarding Q5 "Do you use it as a luggage storage space?" from Section 3.3, overall, more than 70% of people do not consider the area around the road to be a place to store luggage. According to Section 4.4, visibility of the road access shape does not have an effect. Also, as per Section 5.4, the size of the site area does not have any effect. However, as shown in Sections 6.1 and 6.2, the change in the number of life elements is affected by the visibility of the roadside space and the size of the site area. Therefore, it appears that residents do not treat life elements as mere luggage.

Regarding Q7 "Are you considering a parking space?", Section 3.3 shows that overall there is a strong tendency to think this way. From Section 4.4, the more visible the road access shape is (ii), the more people think this way. However, the p-value of 0.147 makes this uncertain. From Section 5.4, when looking at the three types of sites, the majority of people think this way in the order of (II) > (I) > (III). This is the same order as the number of observable life elements in Section 6.1. This is thought to be due to the fact that bicycles and cars are a life element.

Regarding Q10, "Do you think the roadside space is being utilized?", the overall average was 3.18,

indicating that 40% of people do not think so at look the section3.3. According to Section 4.4, visibility of the road access space does not have an effect. From Section 5.4, (II) residents of "small site" have an average score of 3.02, which is 42.2%, a high figure. However, the *p*-value of 0.430 makes this uncertain.

Regarding Q11, "Do you think that leaving luggage, bicycles, cars, plants, etc. in the roadside space helps prevent crime?", from Section 3.3, 30.4% of respondents overall thought it was helpful, while 55.5% did not think it was helpful. According to Section 4.4, visibility of the road access shape does not have an effect. From Section 5.4, when looking at the three types of site, the tendency to think that (III) is more useful than (II) is more likely to be useful than (I). (I) 67.9% of residents living in "extremely small site" did not think it would be useful.

Regarding Q13, "Are you concerned about not having a fence and having your property visible from the road?", the overall average was 2.64, with 53.6% of people having objections and 32.3% not having objections, based on Section 3.3. From Section 4.4, many people are opposed to (i) the lack of visibility in the road access shape. From Section 5.4, the number of people who are resistant to (III) > (II) > (I) is highest.

Regarding Q15 "If there is a fence, do you store items behind it?", the overall average was 3.82, with a difference of 3.3, meaning that approximately one-third of the respondents answered that they store luggage behind fences. As per Section 5.4, the size of the site area does not affect the property.

6.4 Consideration of the Relationship between Site Size and Life Elements

From Sections 6.1 and 6.2, (I) small sites have more life elements that can be seen in the roadside space than (II) extremely small sites. However, (I) extremely small sites have more life elements spilling onto the road from the roadside space than (II) small sites. From a physical perspective of the size of the site area, one factor that is thought to be the physical lack of space in the roadside space is that extremely small sites (I): sites of less than 70 m^2 are smaller than small sites (II): sites of 70 m^2 to less than 100 m^2.

In addition, general sites (III) have the fewest life elements that can be seen in the roadside space, and the fewest life elements that spill onto the road. From a physical perspective of the size of the site, it is thought that in detached residential areas, the larger the site area, the larger the building area. One of the reasons for this is thought to be the ample interior space within the building where life elements can be placed (Fig. 27).

6.5 Life Elements and Residents' Attitudes in the Roadside Space in Detached Residential Areas with Many Small Sites in Urban Areas

In Fig. 1, the area around the road is a space that is affected by both the road side and the detached house side. We then stated that a distinctive feature of this study is that it focuses on the life elements that are present within it. Based on the results of this survey, life elements are examined from the perspective of quantity. In the survey area, it can be observed that urban residents arrange their various life elements in response to their physical living environment. Life elements may be located on the roadside, in the roadside space, or inside the home. These factors create a living environment unique to cities (Fig. 28).

Urban residents have a variety of attitudes toward roadside space, as shown in survey results Q1 to Q4. Furthermore, as shown in survey results Q5 to Q10, there are a variety of ways to utilize the roadside space. Look at life elements from the perspective of quality. The life elements play various roles, such as "luggage, streetscape design, bicycle parking, car parking, crime prevention, and as a substitute for a fence." Furthermore, residents' awareness of and treatment of life elements differs. In this study, the life elements shown in Fig. 6 were treated as equivalent and investigated in a unified manner. However, residents' awareness of each life element differs.

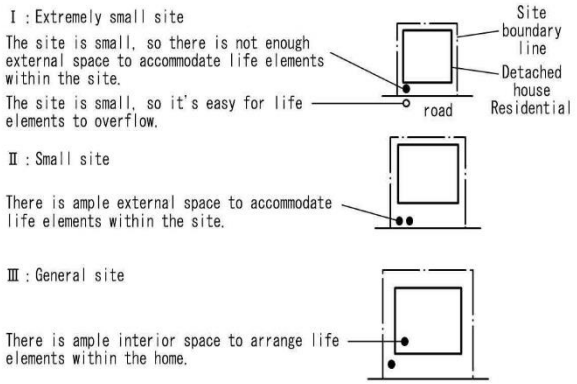

Fig. 27 Arrangement of life elements for three types of sites.

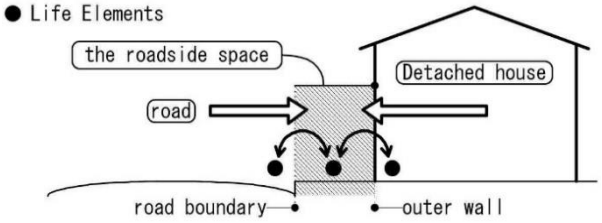

Fig. 28 Characteristics of life elements in the roadside space.

6.6 Future Outlook

In this study, we evaluated the amount of life elements in detached residential areas in urban areas where many sites are small. It was revealed that the amount of life elements is affected by the road access shape and the size of the site. In addition, a resident questionnaire was conducted to investigate residents' awareness of and usage of the roadside space. From these findings, it was found that life elements have diverse characteristics and roles. The results of this survey showed that in some cases more than 100 specimens could be observed, while in others only a few could be observed. They are not able to consider each life elements. In particular, bicycles and cars were observed in large numbers. In the field survey, these factors appeared to have a significant impact on the spatial structure in the roadside space. By exploring the relationship between the area around parking spaces and other life elements, we believe it will be possible to consider the spatial composition in the roadside space on small urban sites.

The target area for this study was a residential area in the city center. If a survey similar to this one were conducted in suburban residential areas, rural residential areas, rural areas, or fishing villages, it would be possible to compare it with this study. We believe that the relationship between life elements and residents can be further examined.

Acknowledgments

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Public Space and Perception of Terror

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Abstract: While people met in order to socialize on public spaces in the past, these areas are perceived as a ‘alone in the crowds’ by people who are in the loneliness of modern era, as well as these areas still serve as a social area. Individuals from all of society, especially minority groups, feel that they are accepted and they show themselves in a way in the public space. Even though the perception and usage of public space have changed in time, people still feel free themselves in these areas. However, ‘terrorism’, which is a reality in today's world, is one of the cases which pose danger to the public spaces. Thus, the image of these areas has changed from “the areas where individuals they feel freer” to “the areas where people are vulnerable to many potential attacks”. This study tells you how the public perception has changed over time and examine the intended use of the public due to these changes. Terrorist activities increased all of the World and public spaces of the individual in the face of this reality, perception and Jane Jacobs, urban life and public relations with the charm of the terrorist phenomenon is one of the main problems the 21st century in the context of views on security are discussed. Also in this report, in order to provide a team recommendation for safe public space taking into account the author's views on security was available. For this purpose, the metropolis of Istanbul is selected as the study area were interviewed and the people living in Istanbul with internet environment. At the end of the 90s until today has changed the perception of how the public and in the public domain when individuals are discussed how they use.

Key words: Public, public space, security, perception, terror, Jane Jacobs.

1. Introduction

'... Refers to the human pattern intertwined. Cities are filled with people doing different things for different reasons and with different objectives, for architecture - about the content, not the format -only this difference reflects and expresses. People are of interest to us because they are human. As in literature and theatre architecture which gives life and colour to the human environment, something that human diversity is a terrific ...’ [1].

Public space is the users' common work. Hannah Arendt and understanding of the public sphere If we look over Jürgen Habermas; According to Onat [2]; understanding of Arendt, the public consists of freedom, equality, word and deed. In this context; understanding of freedom based on considerations regarding the freedom that exists in the ancient Greek city-states. Freedom in ancient Greek that the establishment of new relations with the citizens 'police' live and refers to the resulting action. Freedom in ancient Greece, it was stated that the presence of the citizens in the public sphere is a political phenomenon. Freedom is experienced with action in this area. Citizens, get rid of the specific areas that they must obtain the identity of the free space when participating in the public space and the political sphere in Arendt's conception of freedom is not taken in connection with the individual's actions. According to Onat [2], the understanding of Arendt's public space; In the public domain 'word' and 'action' is the basic condition of no plurality. According to Onat [2]; The function of the public sphere is communication in Habermas's conception.

Onat's [2] Habermas and Arendt examination in her book that gave a place to study; Habermas's public sphere definition / conceptualization is open to everyone in the prominent point, is not accountable to society members, political control, it is mentioned that the common interest such as spots. In Arendt's understanding of the privacy of private space, which is

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dominated by the ruling; While in areas where there are no other words to political events; The public space where there is freedom, which consists of political events, emphasizes that the emergence of the field of view means to be human. According to Onat [2]; The collapse of the public domain and on the other side of the urban phenomenon of the identity of the individual, in other words, freedom is being destroyed the state. Public Space And Borders book stated in today's modern society no longer be talking about public space where everything commodification and the money that we live in a time when fetishized society and mass society refers that takes the form. Subsequently; Mass society has no political space. People, alienation towards the world and society lives in a profound way. This state of alienation in making a lot of people are eliminating their space to express themselves. Mass organizations in the community to deviate from this or that his own purposes; It is becoming an element of interest and pressure. In this kind society; There already seems to be negligible in the form of word and deed. These events are not taken into account that not make life easier. Moreover, each event becomes at this point is based on pragmatism. This Word describes the current situation.

While people met in order to socialize on public spaces in the past, these areas are perceived as a ‘alone in the crowds’ by people who are in the loneliness of modern era, as well as these areas still serve as a social area. Individuals from all of society, in particular minority groups feel that they are considered public domain and are a way to show themselves. Time perception and usage in public places has changed. Individuals from all of society, especially minority groups, feel that they are accepted and they show themselves in a way in the public space. Even though the perception and usage of public space have changed in time, people still feel free themselves in these areas. However, ‘terrorism’, which is a reality in today's world, is one of the cases which pose danger to the public spaces. Thus, the image of these areas has changed from “the areas where individuals they feel freer” to “the areas where people are vulnerable to many potential attacks”. to assess the public perception in Istanbul; the planning decisions taken in Istanbul to investigate the background in mind, will help us better grip.

2. Planning Movements in Istanbul and Background

Von Moltke plan is defined as the initial plan in Istanbul planning (1837). After that Maria De Lavnay (1864), Carl Chr. LÖRCHER (1922-1928), Herman Elgötz (1933), Alfred Agache (1933), Jack h.lambert (1933), Henri Prost (1936), Martin Wagner (1938), Piccinato (1960) and Turkey planners in the aftermath of 1960 which it is located by the work plan. The second half of the 19th century co face of the change in the social structure of Istanbul faces has been space change. Ilhan Tekeli [3], this exchange of fire places and with the positional plans for places opened to new residential and treating it as a change sought to be guided by regulations 19th century until the second half of the republic's anniversary last time, 'it is called 'shy modernity years’.

In 1923, with announcement of the Republic has started a new era. For years, the capital has lost this identity with titles Istanbul to Ankara. It has entered into the socio-economic transformation in Istanbul with the loss of this power management [4]. Between the years of 1923 to 1928 period, Turkey is known as the unplanned development. During this period, Istanbul's plans were prepared by Carl Lorch [4]. In this process, especially Istanbul square, green spaces, focused on transportation [3]. 1930-1950 years are an important period in terms of development from Istanbul. This period has been a great change in terms of Istanbul, especially since the postwar period.

When we look at planning activities take place in Istanbul, we see the devastation. This can be seen most significantly in four periods:

- Cemil Topuzlu Period (1912-1914)
- Lutfi Kirdar Period (1938-1949)

- Fahrettin Kerim Gokay Period (1949-1957)
- Bedrettin Dalan Period (1984-1989)

3. Public Space

'Never in a city that does not belong to one of their own people constantly try to leave a mark on their life stories'

Richard Sennet

'Public space, in English public (belonging to the community) and space (space) is the ink of the words' belonging to society "as explained. 'The first known use of the word in the English public' community of common interest "when the sense, the end of the seventeenth century ', which is open to everyone audit' began to be used in the sense ' [5]. According to Habermas [6]; 'A public function, firstly it has emerged around the UK at 18th Century. ' Public space for people to socialize and they are areas that act as a meeting place for different segments of society from each other came together people with very different characteristics. Periodic daily routine activities, functional and ceremonial activities that take place in society, linking public and private sphere of the individual separation of their privacy be traced back to antiquity. Greek city-state of free citizens that use the common (placing) the area of the police, the use of which belong to third parties (idian) are separated strictly from oikos area. The public space 'bios politikos', in the market square, has emerged in the Agora. In the consciousness Greeks, public; rises as a realm of freedom and stability across the private area [5].

Public space is an expectation that the field definitions for all the emergence and development of publicity is expressed as follows: Greek city states began to join together with the management to come up with citizenship cases non-existent until then is led to the emergence of the concept of publicity. The places where people come together, although there is as of today's date much earlier in publicity terms of power sharing and justice has emerged with the distribution period is not achieved only.

With the definition of Gökgiz [7], public spaces; social activities (opening ceremonies, election campaigns, festivals), cultural events (street theatre, concerts, religious ceremonies), shopping, sports activities, the commercial function in which the political and trade union activities are open areas where [8] public areas are classified as follows:

3.1 Open Public Spaces

3.1.1 Open Public Spaces: Remaining within the boundaries of a city or a residential community, directly or indirectly, environmental, social and economic benefits that provide or ensure all areas are not built with the potential.

3.1.1.1 Green Spaces: as a sub-title of the outdoor spaces in urban areas, leafy water or geographic areas containing features;

- Parks and gardens,
- Comfortable green areas,
- Children playgrounds,
- Sports facilities,
- Landscaped passages,
- Natural and semi-natural green areas,
- Other functional green areas can be grouped under this heading.

3.1.1.2 Open to Public, public spaces: As a sub-heading of open spaces, public-serving, city squares, market places are areas such as alleys.

- Squares,
- Market places,
- Sidewalks,
- Navigation areas and coastal areas.

3.2 Squares

Town squares, is the most efficient use of urban open spaces items. The town square, on special occasions by the urban social, cultural, political, and used for commercial purposes, briefly passes of urban life is an important public venue [9].

Squares designed as an extension of contemporary social life in the early days of the Republic, is used

more as a park and parade ground today.

3.2.1 Shape of Squares

To classify a way that takes the square have been many attempts so far. They are mostly accepted the theory of two one [10] have been revealed by. The challenge for his work on Zucker occurred were classified as five archetypes. These:

- The location is kept in its own (as an independent) off the main square,
- Venue managed to challenge the dominant main building,
- Space is built around a central nuclear it occurs,
- combined to create longer compositions grouped consisting of spatial units' squares,
- They are formed amorphous space without any limit.

Zucker, squares, square type based on examples from his work as specified in the related [12];

Fig. 1 Closed Squares.

Fig. 2 Dominant Squares.

Fig. 3 Nuclear Squares.

Fig. 4 Grouped Squares.

3.3. Streets

"The city's streets and there should always be active living should be checked by employees." J.Jacobs

'Very nice, I live in a quiet residential area, "says a friend who had to sit in the search for another place. 'The only noise at night from time to time the cry is going on at the victims of the attacks took place. "For fear of the people on the street in the street or district does not need to occur much more violent incidents. Moreover, the less fear that people in the street and this street in order to reduce their streets' [1].

'Barbarism and vandalism that causes real fear, not damgalana as the problem of non-imaginary feeling of insecurity slums. In fact, places where this problem is most severe, the kind that decent looking to leave my friend 'are places of quiet residential area' [1].

'The presence of foreigners as to deal with strangers and always be successful in the streets of the neighbourhood itself should be the three qualities of a street equipped to create a law-and-order possibility:

First, it should be no clear boundaries between public space private space. Public and private areas not penetrate into each other like in the suburbs or in public housing;

Second, the streets of eyes watching, so should be the eyes of the people might call natural owners of the street. Turn back the empty side of the street or streets blinded they should not;

Third, there must be someone on the sidewalk and almost always effective and should increase the number of eyes facing the street, as well as a certain segment of the residents in the street in the building should create

an excuse to look to the street. Nobody stood in front of the door or window cannot sit like looking at an empty street. Almost no one does a thing like that holding. On the contrary, many fixes occasional boredom by watching the activities of people in the street '[1].

3.4 Sidewalks

'The fundamental characteristics of a successful neighbourhood walking among all these strangers on the street is people feel themselves safe. They should not have the feeling threatened by it. This residential neighbourhood is a bad business interests in other areas that fail and result in trouble such as mountain for both him and the city in general' [1].

3.5 Parks-Gardens

Parks, one of the public spheres according to Özdemir [12], defined urban spaces that function as urban parks, because they bring together people with individual places and icons is that they helped facilitate communication between communities.

3.6 Kıyılar

According to Ferudun [13], coast should occur in accordance with the status of public goods in the Constitution, as well as a number of arrangements have been made in the Coastal Law and other legal rules. Accordingly, our coast is clear to everyone that the quality of public goods and thus is subject to the principles of public law relating to public goods. These principles;

- The coasts are under the sovereignty and disposal of the state.
- Coastal and speed and cannot be surrendered.
- Coastal is not sequestrated.
- Coasts are not available through Timeout.
- Coastal will not be expropriated.
- Coastal, are protected in different ways from the private person of goods.

3.7 Public Space Security

'The first thing that must be understood, public peace in the city - the sidewalk and street peace - protection of business, although the presence of the police forced first is that done by the police. The people who live there to protect the public peace complicated, moreover, almost unconscious voluntary controls and standards network; moreover, it is itself also implements public. ' (Jane, 2005)

'The second point that should be understood, distributing people in a wider area, it can not solve the problem of suburban properties instead of passing the order of city properties. If this were a solution would have to be a safe city of Los Angeles; because it is a city that is almost entirely composed of the Los Angeles suburb. cramped quarters until order to qualify as a busy city area is almost no. But in Los Angeles, like other big cities, it cannot escape the fact that it consists of non-cute alien' [1].

4. Survey Data and Evaluation

The scope of field work in a web environment, for example in the province of Istanbul with 206 people was conducted survey. When examining the results of the participants for the survey; 56.8% were female, 43.2% consists of men. 80.5% of respondents university students / graduates, while 14.1% Master / PhD students / graduates said they are in. Participants to the questions they had lived while in Istanbul against 40.3% in the 0-5 year range of options mark was 25.7% for 25-30 years if they live in Istanbul. asked for public space for the public perception of the participants represent the best assessment which respondents to the question; 34% of parks, squares of 31.7%, 19.9% 'roads (streets, roads, boulevards), while 14.6% gave the answer coastal areas. According to the results the participants perceive public space as more parks and squares. Public space What often do you use public spaces that we have asked with the aim to find out the frequency of use, more than half of the respondents to the question if the majority of the rest, while the answer every day has responded several times a week. Which do you use more often from the

public sphere in question, while the other to answer the question 64.4% of ways, the answer as 14.4% and 10.7% coastal parks and squares. Looking at the period of time that they use, it is seen that a very large proportion of the day intensive use. Weekday and weekend seems to be busy during the week, when we compare the use of use. This suggests that the high intensity of use of public space in the working hours. This shows that when viewed from the context of several definitions of public space; a liberation of the socializing area, according to the survey results public spaces rather than in the public domain meaning 'transition area' is to find the definition. Looking at the time they have spent in the public sphere min 1 hour and 5 hours between the time they spend the majority of them (30.6%) were seen in 2-3 hours they spend in the public domain. 45.6% of respondents to the question of what it means to the public than those respondents social activity area, the area of freedom 30.1%, while 19.4% were found to satisfy leisure activity areas.

As a result of the questions, you have asked in the framework of public safety in the last part of the questionnaire;

Themselves in the public sphere in confidence that they think they are the 32% safe questions they feel-feel, without any notion of 25.2%, they are not in the trust of 19.4% and of a 16% portion, they definitely feel absolutely safe that they thought that the security problems and the vast majority (53.9%) stated that they did not feel safe because of the terrorist attacks.

5. Conclusion

Public space, in the past, while the areas they met in person in order to socialize, if within the individual in the modern era loneliness' alone thick of crowds' 'As well as perceived areas remains the distinction of being social area. Individuals from all walks of society, especially minority groups in the public sphere in a way to show themselves and they feel that they are accepted. The distinction of being the areas where they feel free to change what individuals in the public sphere in public perception and use of time is preserved. But today's reality is one of " terrorism " being the case constitutes a danger to the public domain and no longer the domain of individuals they feel more free public spaces are transformed into areas where they are vulnerable to many potential attacks themselves. Public space is perceived as a centre of attraction by terrorist groups, it is turning to the potential attack surface by other individuals. Since the middle 20th century 's development level of the country has been a threat for many countries no matter the terrorist phenomenon and terrorist activities, in order to undermine confidence in the authorities and arouse greater repercussions, because they people have tended to place in the public sphere are heavy users of public space and terrorist perception issue It is important for almost all countries. Full of life, in considering that the area is controlled by the surrounded and a constant eye to building a more secure areas, the answer is controlled by the terrorist attacks recently increased with the question of the 43.9% the police and become areas of concern of the public space of the terrorist attack reveals the attractiveness of public spaces of terror cases.

It is understood from the results of the survey, the fact that a world of terror; public spaces could be seen as the areas they felt themselves free by the user in the past, nowadays open to terrorist attacks are seen as potential areas of action. In this case people to limit and restrict the public's freedom.

Today, the public space for the growing terrorism, to ensure security should be planned primarily as a living space in those areas. Like emphasized by Jane Jacobs:

‘The basic characteristic of a successful neighborhood walking among all these strangers on the street is people feel themselves safe. They should not get the feeling was threatened by them. This residential neighborhood is a bad business interests in other areas that fail and result in trouble such as mountain for both own and the city in general.’

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Integrating Green Building Index Consultancy with Residential Building Design

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Abstract: Despite government incentives, developers are reluctant to invest in green building initiatives due to their perceived extra costs – in particular additional consultant and construction implementation costs. This paper examines the issues preventing the integration of Green Building Index (GBI) consultancy with residential building development in the Malaysian construction industry. Following a literature review of the challenges involving GBI consultancy at the early stage of green residential development, a semi-structured interview method was used to elicit opinion on perceived barriers to integrating the GBI process from 30 interviewees; mainly developers, GBI consultants, building consultants and regulators in the Malaysian construction industry with involvement in green building. The study found that a lack of communication between design team members and GBI consultants was a major barrier. This reduced the opportunity for a more collaborative effort to minimise costs and wastage during the design stages. Lack of insight into the impact of integrating the GBI consultancy into design process within the project time frames was evident. Effective coordination is necessary if the involvement of GBI consultants, particularly at early design stage, is to be successfully managed. It is recommended that work coordination among design team members and GBI consultants needs periodic review.

Key words: Green building index consultancy, early design stage, residential development, Malaysia.

1. Introduction

The Malaysian Construction Industry Master Plan (2005–2015) pinpointed sustainability as being indispensable in the Construction Industry Development Board [1]. Green Building Index is an extensive rating system and environmental assessment tool used for appraising the environmental design and the performance of buildings [2, 3]. The rating system had strong support from the government through income tax deductions equivalent to the additional capital expenditure incurred by building owners in obtaining GBI certification from 24 October 2009 to 31December 2014, and stamp duty exemption for the first owner of a green building [4, 5]. Construction stakeholders are beginning to implement the concept into their designs and projects.

The government has identified residential building development as an essential human requirement and an all-important ingredient in the nation's economy and it is used as part of the government's political strategy to achieve both its social and economic goals [6]. It is noted that the building industry alone contributed about 3-5% of Gross Domestic Product (GDP) and provided employment for close to 10% of the total labour force (Ministry of Finance (MOF)). In the 10th Malaysian Plan (EPU, 2010), it is projected that, urban areas in Malaysia alone will need to accommodate six million more residents between 2012-2020. Despite increased demand for residential buildings [7], green building practice is not yet a commonplace in residential building development. It is apparent that developers rarely engage the services provided by GBI consultants in their projects [8]. Therefore, it is important to get an appropriate understanding of the current scenarios and barriers to GBI implementation at early design stage in residential building development.The development of general strategies to improve acceptance of GBI

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consultancy in the construction industry whilst utilizing the expertise of professionals and regulators from both public (local building authorities and construction agencies) and private sectors (architects and planners) is imperative and it is the aim of this paper.

2. Literature Review

A brief description of GBI Consultancy, the rating tool and its categorization, and an overview of the link between residential needs and green practices are reviewed in the following section.

2.1 Green Building Index Consultancy

Green Building Index consultancy is a process of getting buildings rated as "green". It is an advisory service to clients in the building industry. This consultancy is focused on enabling architects, engineers, urban designers, developers, public authorities, contractors and other construction professionals to identify the benefits of considering sustainability within a construction project benefits such as reduced operational cost, improved resource use, waste minimisation, energy efficiency, the use of renewable energy and other innovative practices which aim to minimise the impact on our environment [9]. However, green building consultants in this context are construction professionals who are involved in green building practices.

The first suitability rating tool, the Building Research Establishment Environmental Assessment Method (BREEAM) was developed in the United Kingdom in 1990 and was brought to Canada in 1996. In 1998, the United States Green Building Council (USGBC) launched its own Leadership in Energy and Environmental Design (LEED) tool while in 2004 the Green Building Initiative (GBI) adapted the Canadian version of BREEAM to create Green Globes and began distributing it in the U.S. market in 2005 [10]. Australia's Green Star was developed in 2003, whereas, Singapore's Green Mark was launched in 2005. Japan's Comprehensive Assessment System for Built Environment Efficiency, (CASBEE) was developed in 2004, New Zealand's version, Green star was launched in 2007 (Prins, 2016) while Malaysia's Green Building Index (GBI) was established by Malaysian Green Building Confederation (MGBC) in 2009 [11].

In GBI rating categorisation, a Platinum rating is awarded to buildings scoring between 86 and 100 points. Buildings are also rated Gold when they score between 74 and 84, and Silver if between 66 and 75. Finally, buildings are rated Certified if between 50 and 65. Available data from Green Building Indexshow that 93 out of a total of 135 green rated residential new construction (RNC) are rated "Certified", 26 buildings are rated "Gold", 10 buildings are rated "Silver" and 4 are rated "Platinium" (see Table 1). For a building to be rated green, it is required to undergo a three-stage certification process. At stage one, Application and Registration,the clients or developers complete the GBI application form, afterwhich a GBI registration number is issued and the terms and conditions are signed between the developer and theMalaysian Green Building Council (MGBC) in which a GBI Certifier is then assigned for the project.

The second stage, Design Assessment (DA) is the process of ensuring that the specified points are met in the design. This will usually involve a presentation by the applicant and their project design team or a Green Building consultant. Upon completion, the GBI Certifier tables the assessment report to the GBI Accreditation Panel (GBIAP). If the assessment is successful, the design is certified as meeting the criteria [12]. At stage three, Completion and Verification Assessment (CVA), upon project completion, the client is required to prove that all the points are met by submitting a CVA usually within 12 months of the completion of the building or when the building becomes 50 percent occupied. The final GBI award isissued by the GBI Accreditation Panel (GBIAP). Points might be lost at this stage. An assessment of the building needs to be done annually in order to maintain their rating [13].

2.2 Green Building Index and Residential Needs

In the seventh Malaysia Plan, the government envisioned 800,000 housing units would be provided for its population [14]. 70% of this target had been realized by the end of 1999. Of the 110,644 units approved by the Ministry of Housing and Local Government (MHLG) for construction in the first six months of 2000, 25.4 % of the approved units were for low cost unit housing, 38.7 % medium cost housing and 35.5 % higher end housing. A total of 57,925 units of residential property were launched in housing schemes in the first half of 2000. Out of these, 39.4 % were condominium/apartment units and primarily concentrated in Selangor and Kuala Lumpur. This huge supply of higher end condominiums depressed the rental market [15].

In the eighth Malaysia Plan in (2001-2005), the country continues efforts to developing affordable and sustainable low and medium cost housing [16]. However, the country was faced with the challenging task of providing between 600,000 and 800,000 houses during a period when the residential construction industry faced various project-related factors that hindered the prompt completion of projects. At the end of 2013, there were 4,718,534 existing residential buildings as against 4,640,269 residential units in 2012 (RHEDA, 2014).

Meanwhile, statistics from MGBC show that, as of October 15 2015, (see Table 1) there were 361 Non-Residential New Construction (NRNC), 271 Residential New Construction (RNC), 20 Industrial New Construction (INC), 21 Non-Residential Existing Building (NREB), 4 Industrial Existing Building (IEB) and 16 Township (T) applications amounting to a total of 693 applications while only 650 were registered representing 333 NRNC, 259 RNC, 19 INC, 20 NREB, 3 IEB and 16 T green building [17]. Only 327 buildings received Green Building Index certification (164 NRNC representing 50% and 135 RNC (41%), 9 INC, 10 NREB, 2 IEB and 7 T representing 10%, 2% and 2% respectively). 118 RNC and 139 NRNC received provisional certification after design assessment while 17 RNC and 24 NRNC received final certification after CVA. It is apparent that green building is not commonly practised in residential buildings while most certified buildings are still at design stage. It can therefore be seen that while there are continous increases in conventional buildings, this is not echoed in the green building industry. The next section reviews the literature on the barriers toward implementing the green practices at an early design stage of residential buildings.

2.3 Barriers Toward Implementing GBI Consultancy

GBI practioners require more knowledge and experience of green principles to effectively cope with GBI requirements. As a result of intricacy of the design process, there could be insufficient or inappropriate

Table 1 GBI Certified Projects by Category.

Update on Green Building Index	TOTAL as of 15 OCTOBER 2015	NRNC Non Residential New Construction	RNC Residential New Construction	INC Industrial New Construction	NREB Non Residential Existing Building	IEB Industrial Existing Building	T Township
Applied	693	361	271	20	21	4	16
Registered	650	333	259	19	20	3	16
Total Certified	327 (100%)	164 (50%)	135 (41%)	9 (3%)	10 (3%)	2 (1%)	7 (2%)
Provisional Certification after DA	276	139	118	5	7	-	7
Final Certification after CVA	50	24	17	4	3	2	-
Renewal Certification after RVA	1	1	-	-	-	-	-

effort put in place for planning and control (Tilley, 2005). In a study on managing the cost of green buildings, Tyagi [18] highlighted that lack of experience with green building technology, components, and energy and water modeling programs can significantly impact the cost overruns. These have become critical issues for the industry.

The demand for green construction as well as the increased cost perception of green buildings means GBI Consultants have to manage green projects with tighter budget and tighter profit margins (Isa et al., 2014). Effectively managing the risks which could lead to cost overrun is essential in green building consultancy. Cost overruns according to Carter & Keeler are common problems in residential development. In their study reviewing the green building demand factors in Malaysia, Aliagha et al. found that the higher costs perceived to be associated with green building may have been based on outdated information and practices [19, 20].

Communication and coordination among design team members and GBI consultants could contribute to enhancing the success of project delivery at the early design stage; they are also required to reduce complications and challenges inherent within the design process of green buildings (Elforgani and Rahmat, 2012).There is rarely enough time for coordination meetings,and to research all the interesting new green materials.Green building consultants only observe the requirements specified in the sustainability guideline without assisting the clients to identify and develop other crucial objectives and requirements for the overall project. It is therefore useful to work out a process for discovery and decision-making ahead of time. The aim of this paper is to understand the barriers toward implementing Green Building index Consultancy and strategies to further improve green practices in residential building development. The strategy of inquiry into achieving this aim and the results of findings are discussed in the following section [21, 22].

3. Research Methodology

To achieve the aim of this paper a semi-structured interview of stakeholder group namely, consultants, developers/owners, builders/property owners and policy maker/regulators in the building construction industry from both private and public sectors was conducted. In terms of selection criteria, interviewees with the knowledge of, and experience in, green building were targeted. A semi-structured interview is one of the most appropriate ways of gathering data on phenomena which are not directly observable and was deemed to be the preferable approach here to generate the essential data for analysis [23-26]. Walker suggests that an interview of this nature requires between 20 and 40 respondents to generate the needed information for analysis. Of the 60 stakeholders sent an invitation 37 agreed to be interviewed. In the event,11 consultants, 4 developer/building owners, 6 builders/property managers from the private sector and 9 Policy makers/regulators from the public sector were interviewed, 30 in all. The data from the interviews were then analysed using discourse analysis. Discourse analysis is the study of social life, understood through analysis of language in its widest sense (including face-to-face talk, non-verbal interaction, images, symbols and documents. It offers ways of investigating meaning, whether in conversation or in culture [27-30]. Table 2 summarises the profiles of the interviewees.

4. Analyses of the Interviews

This section discusses the analyses of the interviews conducted. The findings were analyzed using discourse analysis and categorised into five themes namely: the stakeholders' understanding of GBI consultancy, meeting the sustainability goal, services provided by GBI consultants, cost related issues, and general strategies to improve GBI consultancy; and concludes by presenting a summary of all the points raised.

4.1 The Stakeholders' Understanding of GBI Consultancy

Interviewees were asked to define GBI consultancy, the aim being to ascertain individual perceptions of the practice. Interviewees were of the view that it is a new field in the construction industry that looks at a wide range of services across the board including architecture, engineering and planning, together with some knowledge of materials. Interviewees C4; C6; B3; P1 and P4 were consistent with their definition that it is a specialist service providing sustainable designs solutions and requires knowledge of every aspect business. Interviewee C3 lamented that there were a handful of firms that purely do green building consultancy while the ones that include analysis work, such as ventilation studies and energy studies are more successful.

Table 2 Summary of interviewees.

POSITION OF INTERVIEWEE	TYPE OF ORGANIZATION OR COMPANY	Code
CONSULTANTS:		
- Architect &Member of PAM	-Architectural consultant	C1
- Engineer & Member of MGBC	-Engineering consultant	C2
- Architect& Member of GBIAP	-Architectural consultant	C3
- Engineer & Member of GBIAP	-Architectural consultant	C4
- Architect & Member of PAM	-Architectural consultant	C5
- Architect, GBI Facilitator & Member of PAM	-Architectural consultant	C6
- Architect & GBI consultant	-Architectural consultant	C7
- Architect & GBI consultant	-Architectural consultant	C8
-Architect	-Architectural Consultant	C9
-Mechanical Engineer & GBI consultant	-Engineering consultant	C10
-Mechanical Engineer & GBI consultant	-Engineering consultant	C11
DEVELOPERS / BUILDING OWNERS:		
-Executive Director & Head of Corporate	- Real estate developer and investor	D1
- Senior General Manager	- Real estate contractor and developer	D2
- Director of Operations	- Real estate developer and investor	D3
- Managing Director	- Real estate developer	D4
BUILDERS/PROPERTY MANAGERS:		
-Executive Director	- Property contractor	B1
-Manager	- Facility Manager	B2
-Managing Director	- Property contractor	B3
-Director	- Project Management	B4
-Director	- Property contractor	B5
-General Manager	- Project management	B6
POLICY MAKERS/ REGULATORS:		
-Assistant Director	- Construction Industry Development Board	P1
-Director	- Construction Industry Development Board	P2
-Senior Architect	- Local Authority under Ministry of Federal Territories	P3
-Director	- Local Authority under Ministry of Federal Territories - Local Authority under Ministry of Federal Territories	P4
-Manager	- Statutory Body under Ministry of Works - Statutory Body under Ministry of Works	P5
-Manager	- Statutory Body under Ministry of Energy, Water and Communications	P6
-Senior Manager	- Statutory Body under Ministry of Energy, Water and Communications	P7
-Senior Technical Advisor		P8
- Senior Technical Advisor		P9

MGBC= Malaysian Green Building Confederation
GBIAP = GBI Accreditation Panel
PAM = Persatuan Arkitek Malaysia / Malaysian Institute of Architects
ACEM = Association of Consulting Engineers Malaysia
C = Consultant; D = Developer/ Building Owners; B = Builders / Property Managers; P = Policy Maker/Regulator

Two property contractors, interviewees B1 and B3opined that providing consultancy services in green building requires an organization or person with the right knowledge and right experience to be appointed to render advisory services on how to go green. The issue of right and adequate knowledge of green principle and practice cropped up during the interviews. This is consistent with the views of Samari et al. [31] on engaging well-qualified personnel with the right knowledge at the initial stage. Only one interviewee (C9) claimed to have a superficial understanding of GBI consultancy, having gone through the GBI rating system. He pointed out that it only focuses people's attention towards green. It can however be generalised that all the interviewees have a good understanding of GBI consultancy.

4.2 Meeting the Sustainability Goal

The opinions of interviewees were sought on how GBI consultation had assisted in meeting sustainability goals. C3 was particularly enthusiastic of the fact that GBI had exceeded its goal in some of the rated buildings. It was further stressed that some certified buildings have exceeded what they predicted in terms of energy saving and water savings.D2 opined that the minimum certification had already given a 20% saving; for anything higher than that, the GBI consultant must know the target in terms cost saving, energy saving and water conservation and not just ticking off points. This interviewee further stressed the missing link is that developers know it is a rating tool but do not understand the target is to achieve 20% reductions. Interviewee C5, on the other hand believes that a lot of time is needed to confirm targets are being met. He perceived the practice is focused on points gathering for financial benefits and not for sustainability. It was argued that if buildings are certified, developers can claim tax and have a lower running cost but the true green is not met as the focus is on money and image(C5). To support the point raised by C5, D1 in his response described the GBI industry as a market place for trading points. This is consistent with some of Prins' (2015) findings in his research into the application of New Zealand Green star sustainability rating tool.

4.3 Services Provided by GBI Consultants

Interviewees were asked to comment on the current services provided by GBI consultants. Some interviewees agreed consultants are very genuine in their practice; they hold on to the spirit of what the green building is really about. Most of the policy makers and regulators, P1, P3, P5, P7, P8, and P9 were impressed by the services provided so far. They agreed GBI consultants are successfully providing the services to the clients. They have made quite a good impact in the industry because of their services(P7). C3, a member of GBIAP, believes that there is need for more GBI consultants as there may not be enough in the industry now because the take up rate in GBI now is very high. It was emphasized that in the early days there was a bit of confusion because some of the fees charged were very high but over three and a half years the price has stabilized and became affordable. This statement is consistent with Darus et al.. It was further stressed that at the inception of GBI in 2009, it was argued that it was a waste of time but now it is seen as worthwhile. However, the real issue is the level of greenness their services have achieved. On the other hand, P2 complained that some GBI consultants are very poor in rendering the services while some are stronger. Those who have done a few projects and possess anin depth knowledge of mechanical and electrical engineering provide a better service than those who do not have that experience (P2).

Interviewee C4a member of GBIAP expressed that they have received a lot of complaints about GBI consultants in the industry who are not doing well due to the way they practise but that developers are actually committed to green building practice. Interview C1, shared that the initial projects were difficult because green building materials were available, there was no

information to show they were actually green. MGBC has now published green pages (The Green Building Products & Services Directory) and most green building materials suppliers have to demonstrate their green content. Also, with the recent Construction Industry Development Board's guideline on green building construction, this whole gap has been closed. Designing with the green rating tool has assisted in closing the design gap, while the procurement gap was closed using green material through the MGBC's green pages(C1).

The three–day GBI consultant training program does not cover the wider field of sustainability. Though seminars, workshops and conferences are organized to train GBI consultants and widen their knowledge of the concept, those without a prior knowledge of green building are disadvantaged. The process of certification is still weak due to some of the GBI consultants not knowing what documentation is required and how to present it to the client. There are no yardsticks to measure the performance of the consultants' services as there are for conventional buildings and developers do not see any need to engage GBIF in their projects (P3). D4 concluded that GBIC must be experienced practitioners, not someone who only completed the three-day training program.

4.4 Cost Related Issues

This section explores some of the cost issues in the mind of industry stakeholdersthat are seen as major challenges to the adoption of GBI consultancy. C7 was of the opinion that reducing green building cost at the early stage could be accomplished by enacting by-laws to address green building in Malaysia. According to him, there are regulations in Europe that glass must be double or triple glazing and the walls all need insulation while Malaysia has only fire rating to prevent fire spread. The new building by-laws coming up have all these things and it is partly driven by Green Building Index rating tools. Once the laws are in place the cost will come up and the base building cost will be negligible. "So when you say green building is expensive it's not true".

C1 and B6 argued that green building is not as expensive as perceived. They claimed it should not cost a lot because in the United Kingdom, the cost is about the same as conventional buildings. Green building materials are still being imported to Malaysia and not locally sourced, with the potential for delays in construction and extensions of completion periods(P9). In addressing cost related issues, Green building consultants' approach to cost effectiveness must be strong enough to critically examine how financially viable the design is. B7lamented that in order to do that, if GBI consultant is fully aware of the rating system it is better to go for a criterion that is low cost or no cost at the first before you actually do one that will take a lot of cost. Then one can have a green building with a very low cost.C5 opined that while the GBI proposes photovoltaic (PV), there is no reason for using solar PV cell unless looking at different energy systems. Everything is about optimisation and how to build sustainability. He argued that to make GBI cost effective is a long process and would require adopting a passive design approach. He further argued that the cost of installing PV cannot be recouped within the PV lifecycle. This is consistent with Applasamy's finding that, the cost to generate per kilowatt hour of electricity by applying life cycle costing (LCC) analysis for a typical household of four using stand-alone PV technology is more than five times the current cost of electricity for residential household.

4.5 General Strategies to Improve GBI Consultancy

Interviewees were given the opportunity to share their opinions on actions to improve GBI consultancy in order to promote green practices in the Malaysian construction industry. They suggested the government need to further encourage and support the implementation of green building practices by providing financial incentives to developers who may require assistance to cope with the increased up-front

costs of resource-efficient technologies in their projects. Suggestions were made that building capacity within the public sector will help to raise the level of understanding in government circles and the political class, thereby bringing the changes in policy and legislation necessary for the implementation of green building practices.

As a way to further improve green building consultancy in the industry, the general public which constitutes an integral part of the client base, require a number of public awareness campaigns and outreach programmes in schools and the media. Educating the public at large about the principles and concept of green building and how it relates to their lives and businesses and the benefits of demanding more sustainable options needs to be a priority. Not only that, incorporating green building practices in the built environment courses taught at tertiary institutions and monitored by the Malaysian Green Building Council and the Malaysian Board of Architects was suggested. In order for a building project to become green it is very important that the GBI consultants be involved at the onset of the project and get a proper direction of the project from the client then see what they think about sustainability and develop its scope. Once this is done, the whole team can actually sit around the table and workshop ideas and apply it to the actual project (D2.2). On the other hand, interviewee C1.9 was of the strong opinion that the services provided by GBI Consultants would eventually be phased out when all architects and engineers are fully experienced in green building technology. Finally, there was clarion call to MGBC to give an annual award to outstanding GBI consultant.

5. Discussion, Conclusion and Recommendation

The interviews revealed that the lack of involvement of the GBI consultants at the initial stage of the green building design process was a major barrier. The incompetence and lack of experience of some GBI Consultants in sustainable design affects design process duration and project resources. The stakeholders stressed poor coordination and ineffective communication among design team members and GBI consultants was a major concern. A more collaborative effort to reducing cost and wastage during design stages was vital. Design team members are required to have integrity and be cooperative, responsive, responsible, courteous, friendly and proactive in dealing with consultants. While better knowledge of the requirements of the client is also required, communication is needed with clients and consultants at all times. Setting up a third party to check the performance of the consultants will help identify the better performers and get rid of poor consultants in the industry. Training the architect to work with the climate and all those concerned is important and the GBI consultants should be part of the setup within the architectural firm rather than an external party. A lot of construction wastage, expensive errors and technical fallout may be averted when competent and appropriate GBI Consultants are engaged. However, ensuring a proper level of service and effective co-ordination with team members are pointers to managing GBI consultancy at the design stage; the introduction of green pages by MGBC has now made it very easy to get green materials and has helped to close the procurement gap in green material supply in the industry. CIDB's new release of guidelines on green building construction has helped to close the green construction gap.

A lack of performance evaluation of GBI consultants engaged in the design stage has hindered their development in Malaysia. It is recommended that engagement of GBI consultants be based on demonstrable skills, knowledge, and professionalism. In addition, they should be particularly responsive to the clients' requirements and feedback. The current green building guidelines should be reviewed from time to time and supported by proper research and decision making at the local level. Better collaboration amongst government agencies is also vital for effective implementation of these consultancies. Finally, a

process for independent third-party evaluation of the performance of GBI consultants is needed to ensure confidence in their skills.

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