

Screening Urban Visual Corridors for Elevated Railways: An Approach Based on a Viewing Orientation Transition Point

¹Hoàng Văn Tài, ^{2*}Lê Thị Thanh Hằng

^{1,2}Hanoi University of Mining and Geology, Hanoi, Vietnam

*Corresponding Author: lethithanhhang@humg.edu.vn; ¹Co-author: hoangvantai@humg.edu.vn

Abstract - At the concept-planning stage, planners need to identify which viewing directions should be examined for elongated structures and whether the dominant viewing direction changes with distance. This study proposes a dual-control workflow with a transition point q^* , defined as the height-normalized distance at which the end face and long side occupy comparable portions of the image frame. Cát Linh Station is modeled from OpenStreetMap; scenarios varying massing ratio, height, and lower-level openness are used to examine result stability. The results show that distance alone is insufficient for selecting a viewing direction: near zones require attention to the end face and lower-level openness, zones around the transition point requires both directions to be retained, while farther zones require control of the continuous extension of the long side. The two modeling approaches produce similar transition points, while increasing lower-level openness shifts the transition point outward. The workflow enables planners to screen visual corridors and rapidly test massing alternatives before detailed modeling. A pilot check using one calibrated field image produced a value within the model sensitivity range. q^* is a comparative indicator under a common camera rule, not a perceptual threshold or a basis for permitting decisions.

Keywords: viewing orientation transition point; visual impact screening; urban massing; frame occupancy ratio; virtual viewpoint; elevated railway station.

Symbols:

VOR: proportion of the image frame occupied by the station;
OR: proportion of the background occluded by the station;
R: VOR ratio of the long side to the end face;
 $q = dC/H$: distance to the station center normalized by height;
 q^* : point at $R = 1$;
 θ : vertical viewing angle;
H: station roof height;
 d_i and d_C : distances to the station outline and center;
 z_0 : elevation at which the solid portion begins.

I. INTRODUCTION

Urban transport infrastructure is both a technical system and a component of the city image. Overpasses, elevated railways, and stations create large volumes that appear from multiple viewing directions and can alter the relationship between pedestrians, street edges, vegetation, and the skyline. A structure may become a positive orientation landmark, but it may also obscure a background object, disrupt street-wall continuity, or create an overwhelming impression at close range. Visual impact should therefore be considered together with massing and spatial organization, rather than addressed only through materials or façade decoration after the scheme has been determined.

Visual impact assessment guidelines emphasize identifying observers, selecting viewpoints, describing baseline conditions, and comparing project-induced change [1]. Practice, however, remains diverse: some studies rely mainly on expert judgment, whereas others use GIS, three-dimensional models, or image analysis [2], [3], [4]. For planners, the gap between computational modeling and design decisions remains important. An indicator that is too complex is difficult to use at the concept stage; conversely, purely qualitative judgments are difficult to verify and reproduce.

Perspective images depend simultaneously on camera position, camera orientation, the image plane, and object geometry. If two alternatives use different focal lengths or elevation angles, their results may differ even when both drawings appear plausible. The study therefore uses perspective projection as a measurement plane with standardized camera settings and frame-clipping rules.

The study aims to establish a viewpoint-based assessment workflow that is accessible to architects and planners while retaining a clear geometric basis. Three indicators are selected: VOR, OR, and θ . The analysis focuses on relationships among building massing, distance, viewing direction, and the urban context; traffic operations are outside the scope of the study.

To address this need, the study proposes the transition point q^* . It can be understood as the position at which the end face and long side occupy equal portions of the image frame. Before this position, the end face may dominate; beyond it, the long side may dominate. The point is embedded in a dual-control procedure: one sample keeps the same setback from the station outline to reflect spatial organization, while the other keeps the same distance to the station center to separate, to some extent, the effect of distance from the geometry of an elongated mass. A parameter experiment further tests the point as massing ratio and lower-level openness change. The output helps planners answer three questions at the concept stage: which corridors should be examined first, when both directions need to be retained, and which massing modifications are worth carrying into comparison.

The study develops q^* by combining central projection, two distance-sampling schemes, and massing-ratio experiments. The contribution lies in recognizing that the dominant viewing direction can change with distance and converting this change into a corridor-selection rule at the concept stage. VOR, OR, and projection are inherited components; q^* , the dual-control comparison, and the planning interpretation are proposed in this study.

II. LITERATURE REVIEW

a) Visual impact assessment

Visual impact assessment (VIA) examines landscape change for different observer groups and specific locations. FHWA guidance organizes the process around context, viewers, existing visual quality, magnitude of change, and mitigation [1]. Palmer shows that VIA has no single technique; expert assessment, public surveys, simulation, and image analysis are commonly combined according to project objectives [2]. The key is not to seek a universal threshold, but to make the selection of viewpoints, measured variables, and interpretation rules transparent.

Landscape guidance also distinguishes the magnitude of change from the value or sensitivity of the context [5]. This study measures the geometric component of visual magnitude; VOR and OR are interpreted together with spatial function, background objects, and design objectives.

b) Image analysis and three-dimensional modeling

GIS and three-dimensional models can determine how much of a structure appears in an image frame and how much background is occluded. Results depend on surface data, model detail, and observer-point placement [3], [4]. Schofield and Cox measured the percentage of an image occupied in a virtual environment [6]; Pardo-García and Mérida-Rodríguez

measured landscape parameters from projected photographs in GIS [7]. The review by Misthos et al. indicates a trend toward combining imagery, terrain, 3D models, and perceptual data [8]. These studies provide measurement tools but do not directly answer a common concept-design question for elongated structures: as an observer moves farther away, when should attention shift from the end face to the long side? This study focuses on that question and does not replace assessment of aesthetic quality.

c) Research gap and questions

Qualitative assessment is easy to discuss within a design team but difficult to reproduce; detailed numerical analysis can require substantial data and software. The study therefore establishes an intermediate screening step with few variables, explicit camera rules, and inspectable image outputs. The central question is whether the position at which the dominant view shifts from the end face to the long side can be identified, and whether movement of that position can support comparison of massing alternatives. Three research hypotheses are proposed:

Table 1: Research hypotheses

Source: authors

Code	Planning question to be tested
H1	Do frame occupancy and vertical viewing angle decrease with increasing distance?
H2	Does the preferred direction shift from the end face to the long side as distance changes?
H3	Does the conclusion remain when massing, camera settings, and data are changed?

The three hypotheses are tested using 12 primary viewpoints, 12 control viewpoints, and a massing-ratio experiment. H1 examines station presence as the observer moves farther away. H2 determines whether the preferred direction shifts from the end face to the long side. H3 examines whether these conclusions remain when data, camera settings, and massing are changed. Statistical measures are used only to examine trends in the selected sample and do not represent all viewpoints in the city.

III. PROBLEM DEFINITION AND STUDY CASE

Cát Linh Station is a terminal station of the elevated urban railway Line 2A, located around the intersection of Cát Linh, Hào Nam, Giảng Võ, and Giang Văn Minh streets [9]. The station has three levels and approximately 18,000 m² of floor area; Line 2A is entirely elevated [10] and commercial operation began in 2021 [11]. For this study, the relevant characteristic is the elongated station mass, which has a direct

relationship with several street corridors and pedestrian-scale spaces.



Figure 1: Context of Cát Linh Station and the 250 m study area
Source: Esri World Imagery (basemap); OpenStreetMap (station outline); authors' editing

This case is suitable for testing the method because the elevated station has a large longitudinal extent, a direct relationship with the street level, and multiple approach directions. Figure 1 presents the spatial context; Figure 2 shows the modeled station mass and the visual-corridor framework derived from OpenStreetMap data. The set of 26 original photographs was used to identify morphology; one image with a clear outline was selected for a pilot quantitative check. Model inputs remain the OSM outline and height scenarios: the planar geometry is extruded by height to construct the perspective-projection environment.

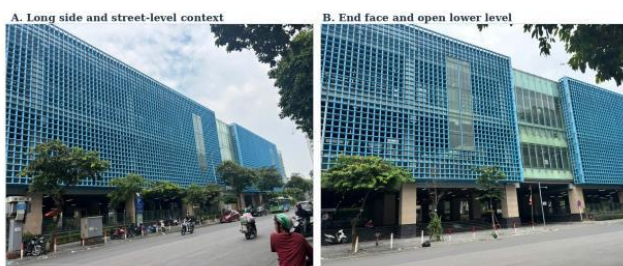


Figure 2: Model of Cát Linh elevated station and visual corridor (using OpenStreetMap data)
Source: OpenStreetMap data; authors' model and editing

Twelve primary viewpoints are arranged along the two axes of the station outline: north, south, east, and west. Along each direction, the camera is placed 30 m, 80 m, and 150 m beyond the nearest station outline, producing viewpoints V01–V12. To control the difference in distance to the center caused by the station's nearly 200 m length, another 12 control cameras are placed on the same four axes at $dC = 130$ m, 180 m, and 250 m. All cameras are outside the station outline; the control set is used only to examine H2 and does not replace the setback sample used for planning interpretation [12].

IV. RESEARCH METHOD

a) Overall workflow

The workflow begins with the corridors to be examined in the planning scheme, followed by camera placement and indicator calculation. The six steps are: (1) obtain the station outline and background buildings; (2) construct the massing envelope; (3) place two camera groups using the same rules; (4) determine frame occupancy, background occlusion, and vertical viewing angle; (5) locate the transition between the end face and long side; and (6) test changes in height, camera settings, background data, and lower-level openness. In each comparison, only one group of conditions is changed.

b) Viewpoint-sample design

The area centroid C of the station outline is the common target point. For the primary sample, d_i is measured from the nearest exterior face of the station along each axis; dC is stored separately in the supplementary data package. For the control sample, dC is fixed at three common levels for all four directions, while d_i varies with the station geometry. The north–south directions view the station end; the east–west directions view the long side. The dual design separates the planning question of setback from the geometric effect of an elongated mass.

The camera center is set at $h = 1.60$ m; images use a 4:3 frame, horizontal field of view $\phi = 60^\circ$, and a base resolution of 640×480 pixels. The camera axis targets the three-dimensional center of the station mass, so the elevation angle β varies with position. This is a geometric comparison standard, not an attempt to reproduce the natural viewing direction of every pedestrian. All viewpoints use the same projection and frame-clipping rules; projected areas outside the frame are not independently scaled to fit the image.

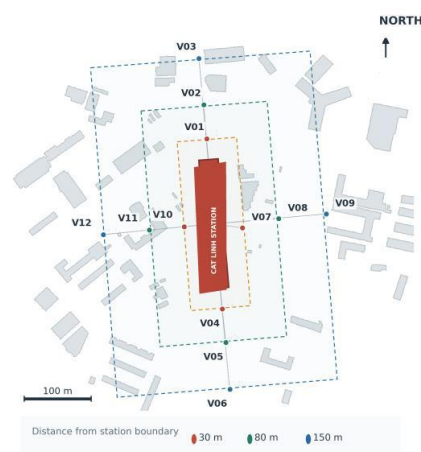


Figure 3: Definition of viewing angle (β) and distance (d)
Source: authors

Table 2: Design of the two virtual-viewpoint sets

Source: authors

Group	Setup	Control
Design	4 directions × 3 levels, two sets	12 primary + 12 control
Position	di = 30 / 80 / 150 m; dC = 130 / 180 / 250 m	each comparison fixes one distance definition
Camera	h = 1.60 m; target at mass centroid	4:3 frame
Projection	H0 = 22.5 m (assumed); $\phi = 60^\circ$	640 × 480 px
Outputs	S, B, O; VOR, OR, θ	raster and tabulated results

c) Central projection model

The model uses central projection with a pinhole camera. Each point of the station and background buildings is projected onto the same image plane; portions outside the frame are clipped according to a common rule [13]. Figure 3 defines the camera geometry used for the comparison.

In practice, two alternatives can be compared only when eye height, target point, field of view, and image-frame size are kept constant. This condition is more important than requiring users to follow the complete coordinate transformation.

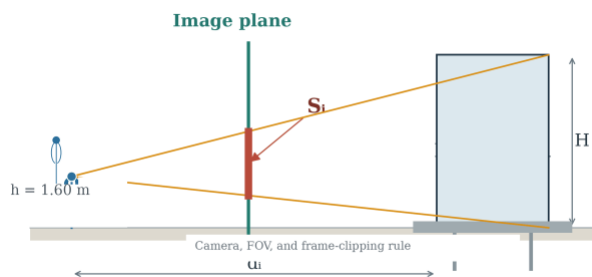


Figure 4: Viewing orientation changes with distance

Source: authors

d) Three visual indicators

VOR is the ratio of the projected station area S_i to the total frame area F_i . The indicator describes the presence of the structure in the image:

$$VOR_i = (S_i / F_i) \times 100\% \quad (1)$$

OR is the ratio of the area O_i of a preselected background object that is occluded by the station to the total background area B_i :

$$OR_i = (O_i / B_i) \times 100\% \quad (2)$$

In the model, the background is the union of the projected building masses located behind the station along the viewing direction. Because the background object changes among locations, OR is primarily used to compare alternatives at the same viewpoint. The vertical viewing angle θ is the angle formed by the two rays from the observer's eye to the foot and roof of the nearest station boundary.

The three indicators answer different questions: how much of the station is present in the frame, how much of the selected background is occluded, and how far the station extends vertically in the view. They are interpreted together with location, spatial function, and the object to be protected in the planning scheme.

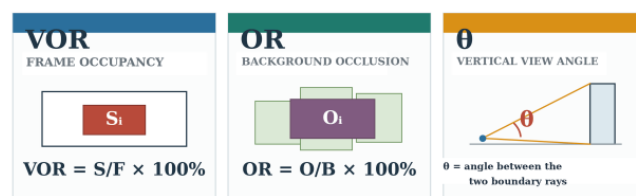


Figure 5: Variation of VOR with distance (schematic)

Source: authors

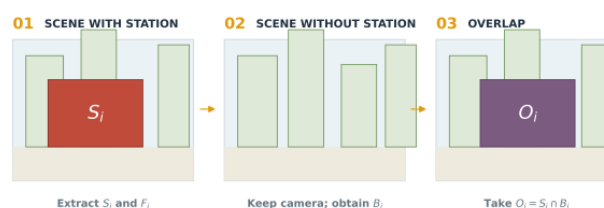


Figure 6: Key elements in the visual corridor

Source: authors

e) Projected-area delineation and OR procedure

The baseline scenario models the station as a solid prism from ground level to roof along the OSM outline; this is a conservative geometric envelope, not an as-built description. Area S_i is the union of the projected roof and side faces after clipping to the image boundary. To quantify the effect of lower-level openness, an additional test keeps the roof at 22.5 m while raising the lower boundary of the solid portion z_0 through four levels: 0 m, 6 m, 12 m, and 18 m. The 18 m level is an extreme hypothetical void below rail elevation, not the actual station form. Vegetation, advertisements, vehicles, and temporary obstructions are not rasterized.

OR is determined from two scenes using the same camera: a scene containing only the background masses and a scene with the station mass added. Background area B_i is taken from the first scene; the portion of B_i within the projected station area forms O_i . Coordinates, target point, β ,

and ϕ are held constant so that the difference arises only from the presence of the station envelope. Foreground structures are not subtracted from S_i ; therefore VOR represents the potential projected scale of the station, not the proportion actually visible after all obstructions.

f) Stability checks

Table 3 summarizes tests of station height, field of view, resolution, background-building height, camera perturbation, distance definition, and lower-level openness. The tests identify which conclusions remain when inputs change, rather than seeking an absolute value applicable to every context [14].

Differences in VOR and OR are calculated in percentage points. Spearman's rank correlation coefficient is used to examine the direction of change in the indicators as distance increases [15]. Results are assessed by differences, viewpoint ordering, and whether the preferred direction changes.

The distance conclusion is considered stable if frame occupancy continues to decrease as the observer moves away in all four directions. The viewing-direction conclusion is considered stable if only one shift from the end face to the long side occurs within the study range. The transition point q^* is the position at which the two directions have equal frame occupancy:

Here, $R = \text{VOR}_{\text{long}} / \text{VOR}_{\text{end}}$ is the ratio of the frame-occupancy ratio of the station's long side to that of its end face. Thus, $R < 1$ indicates end-face dominance, $R = 1$ indicates equal occupancy, and $R > 1$ indicates long-side dominance.

$$R(q^*) = 1, \text{ with } q^* = dC^*/H \quad (3)$$

Table 3: Stability checks

Source: authors

Check	Scenario	Indicator
Viewing distance	30 / 80 / 150 m	angle difference
Image geometry	H = 20.5–24.5 m; 50°–70°; two resolutions	value, ranking
Context	background 16 / 19 / 22 m; z0 = 0 / 6 / 12 / 18 m	VOR, OR, q^*
Viewpoint	position ± 5 m; direction $\pm 3^\circ$; two distance definitions	ranking, transition count
Field image	1 EXIF image; position ± 2 m; elevation $\pm 1^\circ$	VOR difference; sensitivity range

Table 4 summarizes results by three distance groups. Detailed results for the 12 primary and 12 control viewpoints are moved to the supplementary data so that the discussion can focus on planning implications.

g) Dimensionless-parameter experiment

To examine the result beyond the Cát Linh case, the study uses ideal rectangular masses with different length-to-width and height-to-width ratios. A q^* map is generated by scanning length-to-width ratios from 1.50 to 8.00 at three groups of height-to-width ratios; the processing code identifies the position at which the two directions have equal frame occupancy. The parameter grid is stored in the supplementary data.

All cases use the same field of view, eye-height/height ratio, and target direction toward the mass centroid. Closer than q^* , the end face dominates; farther than q^* , the long side dominates. q^* is not determined for symmetric masses or when the long side already dominates at the nearest position. q^* supports massing comparison only under the same camera setup.

V. DATA AND MODEL CONTROL

a) Measurement framework and source data

OSM data were retrieved on 3 September 2026 within a 500 m window around the station, including the station outline and surrounding buildings. Most background buildings lack height attributes; therefore low, baseline, and high scenarios are used for sensitivity testing. The H1-3 urban zoning plan [16] supports contextual identification only; assumed heights are not interpreted as mandatory plot-level standards.

The station outline is approximately 195 m long and 33 m wide, with a length-to-width ratio of 5.91. The plan area inferred from OSM is close to the published floor area [9], providing a reasonableness check for the massing envelope at the screening stage. A roof height of 22.5 m is the baseline assumption and is tested at two nearby levels; 18 m is only a test boundary for lower-level openness and is not an as-built measurement confirmed by this paper.

b) Data control

The control procedure ensures that projected areas do not exceed the image frame, occluded background does not exceed the background area, and all ratios remain within valid ranges. Results for each scenario are stored separately for rerunning and cross-checking.

c) Hypothesis checks

H1 is examined by the trend in each direction. H2 is read successively at the same setback and at the same distance to the station center to avoid confusing the effects of station geometry with distance. H3 changes each input group and checks whether corridor ordering and q^* position remain stable.

VI. RESULTS AND PLANNING DISCUSSION

Results are presented in two parts. The first addresses the planning problem: which corridors should be examined and which massing changes are worth testing. The second presents the indicators used to examine that assessment. The baseline scenario is a solid massing envelope with an assumed height of 22.5 m; the control set keeps the same distance to the station center to compare the end face with the long side.

Table 4: Mean results for the solid massing envelope by distance

Source: Authors' calculations

Group	n	di (m)	VOR (%)	OR (%)	θ (°)
Near	4	30	67.26	93.72	37.92
Medium	4	80	21.34	55.47	15.79
Far	4	150	10.25	47.53	8.54
All	12	—	32.95	65.57	20.75

Frame occupancy and vertical viewing angle both decrease as the viewpoint moves farther away. From the 30 m group to the 150 m group, mean frame occupancy decreases by approximately 85% and vertical viewing angle by approximately 78%. From a planning perspective, this indicates that spaces close to the station should be screened first, especially pedestrian approaches, intersections, and openings at pedestrian level. The tested distances are not control radii or mandatory setbacks.

If the same setback from the station exterior is maintained, the long side appears consistently more important. When the same distance to the center is maintained, the end face dominates at the near position, while the long side dominates at the two farther positions; the transition point for the station outline is $q^* = 7.10$. The result indicates that an elongated structure should not be represented by a single fixed viewing direction. OR is more sensitive to background configuration and is therefore suitable mainly for comparing alternatives at the same location and camera.

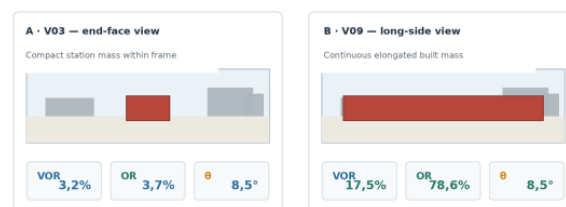
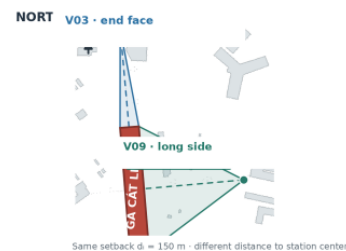


Figure 7: Two viewing directions at the same $d_i = 150$ m but different d_C

Source: authors

Table 5: Effect of lower-level openness on the preferred viewing direction

Source: authors' calculations

z_0 (m)	R; $d_C = 130$ m	R; $d_C = 180$ m	R; $d_C = 250$ m	Transition q^*
0	0.42	1.54	2.61	7.10
6	0.42	1.44	2.45	7.22
12	0.39	1.24	2.08	7.51
18	0.33	0.92	1.55	8.32

Figure 8 shows how massing ratio affects the transition region. Within the tested range, a long and low mass maintains end-face dominance farther away; a taller mass shifts to long-side dominance earlier. For the Cát Linh station ratio, the ideal rectangular mass and the detailed outline give similar q^* values, 7.17 and 7.10, respectively. This proximity indicates consistency between the two models in the case examined, but does not demonstrate broad applicability. For planners, the map helps identify where both the end face and long side should be retained in the comparison set.

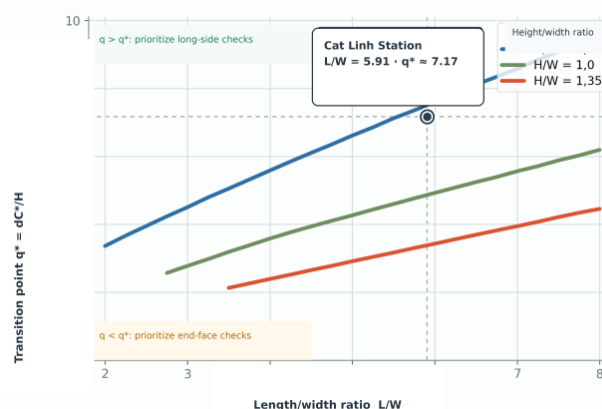


Figure 8: Effects of station volume ratio on visual corridor

Source: authors

Changing height, field of view, and resolution changes absolute values but does not change the group of four viewpoints that should be checked first. Position and camera-direction perturbations create larger local variations. Therefore, results are more reliable for corridor ordering; when comparing specific ratios, planners should keep the camera, field of view, and frame-clipping rule unchanged. Check values are provided in the supplementary data.

Background-building height scenarios do not change the main conclusion, but some points show clear variation in occlusion. This supports using OR as a site-specific indicator rather than as a score for directly ranking streets in different contexts.

Lower-level openness is the design variable with the clearest effect. When the lower boundary of the solid portion is raised from 0 m to 18 m, mean frame occupancy decreases by more than half, while the four priority viewpoints remain unchanged. q^* increases from 7.10 to 8.32 (Table 5), meaning that the zone requiring attention to the end face extends farther before the long side becomes dominant. The result supports testing lower-level openness and visual permeability during massing formation; it is not sufficient to prescribe a specific openness ratio.



Figure 9: Pilot quantitative check using image IMG_2723: (a) traced geometric outline on the image; (b) projected massing envelope in the calibrated camera. The shaded area indicates the potential outline, not the surface remaining visible after trees and vehicles

Source: field photograph by the authors and authors' calculations, September 2026

In the central calibrated configuration, image-outline VOR is 79.8%, while modeled projection is 80.7%, a difference of 0.9 percentage points (Figure 9). When position

varies by ± 2 m and elevation angle by $\pm 1^\circ$, modeled VOR ranges from 75.8% to 86.3%; the image value lies within this range. The result indicates that the model can reasonably reproduce the station outline in one representative direction, but this is not an independent validation because position and elevation angle were still fitted from the image. Trees, vehicles, and the lower-level void are not subtracted from the outline; they indicate that the pedestrian-level experience may be less visually massive than the computed envelope. For planners, the model is suitable for selecting corridors for early review, while massing decisions still require consideration of openness, column rhythm, and actual obstructions.

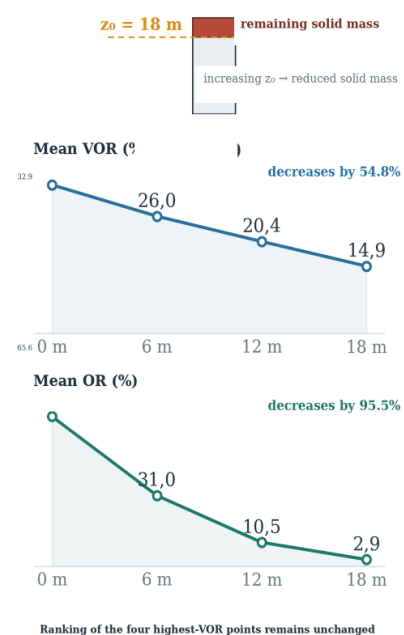


Figure 10: Impact of low-level openness on visual corridor
Source: authors' calculations

VII. USE OF THE METHOD AT THE CONCEPT-PLANNING STAGE

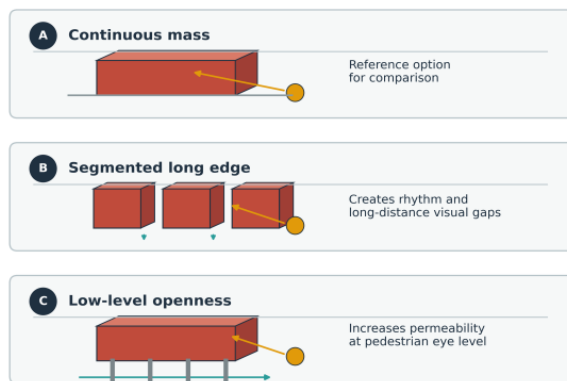
a) Pilot image-based field check

The September 2026 field campaign produced 26 image frames; consecutive frames were used only to select a clear image and are not treated as independent observations. The pilot check uses the original IMG_2723 image (5,712 × 4,284 pixels). EXIF records a focal length of 5.96 mm, equivalent to 26 mm; the derived horizontal field of view is 67.3°, heading is 270.2°, and horizontal positioning error is 16.9 m. The coordinates were used as an initial position and then matched to the sidewalk edge identified in the image and map. Elevation angle is not recorded in standard EXIF: an initial value of 16.5° from phone orientation data was adjusted to 18° because the handheld device's tilt sensor is subject to measurement error; the adjustment was checked against the

roofline, vertical line, and building foot; camera height remained 1.60 m. To use the same definition as modeled VOR, the image was traced along the geometric outline from roof to ground and bridged across portions obscured by trees and vehicles; it does not represent only the visible surface. Sensitivity uses position ± 2 m and elevation angle $\pm 1^\circ$; OR was not recalculated because the background object could not be separated consistently. The initial elevation angle of 16.5° was taken from the handheld device orientation sensor, but the sensor value was affected by handheld tilt and was not sufficiently reliable for image-plane reconstruction. The angle was therefore refined to 18° by checking the roofline, vertical building edges, and station ground reference in IMG_2723. This adjustment is treated as an image-registration step rather than independent validation.

SAME VIEWPOINT • SAME CAMERA CONFIGURATION

Screening identifies where massing alternatives need further comparison



Compare VOR, OR, and visual form; not a permitting threshold.

Figure 11: Field photo IMG_2723 with camera position and viewing angle

Source: field photograph by the authors, September 2026

b) Role in scheme development

The shift of q^* with increasing lower-level openness z_0 is particularly relevant to concept planning. In the tested range, raising z_0 moves q^* outward from 7.10 to 8.32. In practical terms within this model, greater lower-level permeability postpones the distance at which the long side becomes visually dominant, so the end-face-dominant zone extends farther before the transition occurs. This means that q^* is not a fixed distance determined only by station height and footprint; it also responds to the openness of the lower level. Therefore, alternative massing options with different ground-level permeability should be compared under the same camera rule rather than assigned a single fixed q^* value.

In an experience-based sketching process, a design team may select a few easily accessible viewpoints and generate images for a scheme that has already been formed. This supports aesthetic discussion but may miss changes in the dominant viewing direction with distance. The proposed

method is used earlier to screen corridors before investing in detailed modeling.

Planners first mark pedestrian routes, intersections, public spaces, and background objects that need protection. Each corridor is then read according to its position relative to q^* : near zones prioritize the end face and lower-level openness; zones around the transition point retain both directions; farther zones examine the continuous extension of the side. Table 6 converts geometric signals into massing tests.

Table 6: From geometric results to planning actions at the concept stage

Source: authors

Model signal	Planning issue to examine	Concept-stage test
High frame occupancy and viewing angle	Station mass may dominate the near visual field	Test stepping back the mass, opening the lower level, or reducing continuity
Viewpoint around q^*	No single representative direction can yet be selected	Retain both end face and long side in the comparison set
OR changes with background and camera	Result depends on site-specific context	Compare alternatives only at the same viewpoint

c) Testing massing alternatives under the same configuration

After priority corridors are selected, alternatives are placed at the same camera position for comparison. Three planning-relevant operations are considered: retaining a continuous massing envelope as a reference, segmenting the long side to create rhythm and visual gaps, or opening the lower level to increase visual permeability. If materials are changed while projected area remains nearly unchanged, the indicators may change little; in that case, perspective images and professional judgment still determine aesthetic quality.

d) Workflow for concept-stage application

At the sketch stage, the workflow consists of: constructing the massing envelope; marking important corridors and background objects; placing viewpoints using the two distance definitions; identifying the preferred direction; testing massing modifications under the same camera; and then concentrating field photography on directions requiring deeper review. OR is compared only within the same context. This workflow reduces the number of images that must be generated while retaining directions that may affect decisions.

e) Limits of planning interpretation

The three tested distances and the transition point are not legal boundaries. VOR and OR values should not be used directly as permitting thresholds. q^* varies with massing ratio, camera setup, and study extent; it only indicates where the ordering between two directions changes in the stated model. The method helps identify where to look and which alternatives to test, but it does not determine which scheme is aesthetically preferable or compliant with architectural regulations. Before planning decisions, results should be read together with existing conditions, regulations, landscape values, and professional judgment.

VIII. CONCLUSION

The contribution is the q^* transition point within a dual-control workflow, used to identify changes in the dominant viewing direction with distance and to select corridors at the concept stage. The Cát Linh case indicates that near zones require attention to the end face and lower-level openness; around q^* , both directions should be retained; farther zones require control of the side extension. A pilot check on one calibrated image gives 79.8% for the image outline and 80.7% for the model, but the result remains sensitive to position and elevation angle. The indicators therefore support screening and comparison under a common camera. OR is mainly used at the same viewpoint and should not be used for cross-street comparison. Planning decisions still require existing conditions, regulations, landscape values, and professional expertise.

IX. LIMITATIONS AND FUTURE WORK

The study has three main limitations. First, the massing envelope and four openness levels do not fully describe structural components, vegetation, and obstructions. For curved stations, domed roofs, or fragmented masses, representative directions should be selected according to geometric axes and access corridors; each direction pair may produce a separate transition point rather than a single q^* . Second, most background buildings lack measured heights; 16 m, 19 m, 22 m, and the station height of 22.5 m are assumed values tested for sensitivity. Therefore, OR is mainly used to compare alternatives at the same viewpoint. Third, field checking has calibrated only one image using positioning and image features, without independent survey control; the 24 modeled cameras on two axes also do not represent the entire pedestrian network. The results demonstrate consistency only for the Cát Linh case and do not establish a common q^* range for other structures.

Future research should calibrate multiple images using independent survey control points while accurately recording

field of view and elevation angle; it should then add background-building heights, station components, and viewpoints along pedestrian networks, intersections, public spaces, and diagonal approaches. OR should be checked in photographs only when the background object can be identified consistently. Replication at stations with different forms and perceptual surveys will indicate whether q^* is sufficiently stable to serve as a reference indicator in design.

SUPPLEMENTARY DATA

Input data, Python code, and sensitivity scenarios are provided in CatLinh_visual_screening_reproducibility_v1.3.zip. The package allows reproduction of the main tables, the data used to construct Figure 8, and the Figure 9 check. The pilot image-based quantitative check includes the original IMG_2723 with EXIF, camera parameters, outline vertices and masks, VOR calculation code, and instructions for reproducing the 79.8% result.

REFERENCES

- [1] Federal Highway Administration, Guidelines for the Visual Impact Assessment of Highway Projects, *FHWA-HEP-15-029*, U.S. Department of Transportation, 2015.
- [2] J. F. Palmer, "A Diversity of Approaches to Visual Impact Assessment," *Land*, vol. 11, no. 7, 1006, 2022, doi: 10.3390/land11071006.
- [3] D. P. Cilliers et al., "A Critical Evaluation of Visibility Analysis Approaches for Visual Impact Assessment," *Environmental Impact Assessment Review*, vol. 98, 106962, 2023, doi: 10.1016/j.eiar.2022.106962.
- [4] R. Wróżyński, K. Pyszny and M. Wróżyńska, "Reaching Beyond GIS for Comprehensive 3D Visibility Analysis," *Landscape and Urban Planning*, vol. 247, 105074, 2024, doi: 10.1016/j.landurbplan.2024.105074.
- [5] Landscape Institute and IEMA, Guidelines for Landscape and Visual Impact Assessment, *3rd ed.*, Routledge, London, 2013.
- [6] D. Schofield and C. J. B. Cox, "The Use of Virtual Environments for Percentage View Analysis," *Journal of Environmental Management*, vol. 76, no. 4, pp. 342–354, 2005, doi: 10.1016/j.jenvman.2005.01.021.
- [7] S. Pardo-García and M. Mérida-Rodríguez, "Measurement of Visual Parameters of Landscape Using Projections of Photographs in GIS," *Computers, Environment and Urban Systems*, vol. 61, pp. 56–65, 2017, doi: 10.1016/j.compenvurbsys.2016.09.005.
- [8] L.-M. Misthos et al., "Modeling the Visual Landscape: A Review on Approaches, Methods and Techniques,"

- Sensors*, vol. 23, no. 19, 8135, 2023, doi: 10.3390/s23198135.
- [9] Hanoi Metro, “Cát Linh Station – Station Information,” <https://metrohanoi.vn/station/ga-cat-linh/> (accessed September 2, 2026).
- [10] Hanoi Metro, “Urban Railway Line 2A,” <https://metrohanoi.vn/metro-network/thong-tin-nha-ga/tuyen-duong-sat-2a-2/> (accessed September 2, 2026).
- [11] Vietnam Register, “Cát Linh–Hà Đông urban railway officially handed over and put into operation from November 6,” November 5, 2021.
- [12] OpenStreetMap contributors, “OpenStreetMap data for Cát Linh Station and surrounding buildings,” <https://www.openstreetmap.org/copyright> (accessed September 3, 2026).
- [13] R. Hartley and A. Zisserman, *Multiple View Geometry in Computer Vision*, 2nd ed., Cambridge University Press, 2004.
- [14] T. Klouček, O. Lagner and P. Šimová, “How Does Data Accuracy Influence the Reliability of Digital Viewshed Models? A Case Study with Wind Turbines,” *Applied Geography*, vol. 64, pp. 46–54, 2015, doi: 10.1016/j.apgeog.2015.09.005.
- [15] C. Spearman, “The Proof and Measurement of Association between Two Things,” *The American Journal of Psychology*, vol. 15, no. 1, pp. 72–101, 1904.
- [16] Hanoi People's Committee, “H1-3 Urban Zoning Plan, scale 1:2,000,” *Decision* 1356/QĐ-UBND, March 19, 2021.

AUTHORS BIOGRAPHY

Dr. Hoàng Văn Tài, Hanoi University of Mining and Geology. Research interests: projection, computational geometry, and engineering mathematical modeling.

Dr. Lê Thị Thanh Hằng, Hanoi University of Mining and Geology. Research interests: planning, urban architecture, and spatial assessment.

Citation of this Article:

Hoàng Văn Tài, & Lê Thị Thanh Hằng. (2026). Screening Urban Visual Corridors for Elevated Railways: An Approach Based on a Viewing Orientation Transition Point. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 10(9), 169-178. Article DOI <https://doi.org/10.47001/IRJIET/2026.109018>
