Road Design — User Manual

Nov 3, 2026 · BESPA Expert Systems

This manual covers the **Road Design** app (Geometric Design of Roads) at **road-design.bespa.online**, as released in October 2026.

1. About the app

Road Design takes a survey of a low-volume road and an Excel input form, and returns a checked preliminary geometric design. The package includes drawings, a workbook, a design report, setting-out data and quantities ready for the Road BOQ Estimator.

It works in nine stages:

- **Survey and horizontal alignment.** It reads and cleans the survey, builds the terrain model and fits the horizontal alignment to your centreline.
- **Vertical alignment.** It designs the grade line around your culverts.
- **Sections, drains and pavement.** It cuts cross-sections and earthworks, designs the side drains and the pavement.
- **Hand-off.** It writes the deliverables and hands the quantities to the estimator.

Three **audit gates** check the design against the standard you chose. Where a check fails, the app revises the design and checks it again. When only you can resolve a failure, it refers the design back to you, saying what failed and what it tried.

You choose one design standard per project. The road type on the form proposes one: Trunk Road (GHA) proposes the Ghana Road Design Guide 2023, Feeder Road (DFR) proposes the DFR standard, and Rural Road proposes TRL ORN. You can override it with AASHTO, DMRB or AUSTROADS.

Preliminary. Every output is a preliminary design aid. A licensed civil engineer must check and seal it before it is used for construction. The app does not design culvert or bridge hydraulics.

2. Getting started

Open **road-design.bespa.online** and sign in with your Bespa licence key.

1. On the **1 · Inputs** card, download the **input template**, or the **Example form** and **Example survey** to see a worked project.
2. Fill in the input form (section 3). Have your survey file ready (section 4).
3. Choose the input form (.xlsx) and the survey point cloud (.csv or .txt).

4. Choose how far to run with **Run to**. The default, **R9**, gives the full design and priced bill. R8, R5, R3 and R1 stop at the gate or stage named.
5. Press **Upload and run**. The page shows a project id and adds it to the page address, so you can bookmark the project and come back to it. To reopen a project, type its id under "Already have a project?" and press **Open**.

While the design runs, **2 · Progress** lights up the nine stages and shows the run log. The page refreshes itself. When it finishes, cards appear for:

- the survey summary;
- each gate;
- the posted speed-limit zones;
- the estimator hand-off;
- adjust and re-run;
- the deliverables.

The editors. Open the editors takes you to a second page. Accept its disclaimer first. The editors let you check and adjust the design by hand:

- review the centreline and the survey kinks;
- check curve radii;
- move the horizontal alignment (accept or re-align a tight curve, drag the intersection points);
- edit the vertical alignment (the vertical-curve table, drag the grade line, pin levels, automatic drainage cover);
- review culverts;
- see the design review and the compliance gate.

Then go back to the workflow page and choose **Re-run from R2** (horizontal), **R4** (vertical) or **R6** (sections). The gates check the edited design again, and a re-run keeps the project's current settings. To change the input form itself, upload it again and run from R1.

Keep your outputs. Projects are deleted after 7 days. Download the ZIP when the design is done.

3. The input form

The input form is an Excel workbook with four sheets: README, 1_ROAD_DESIGN, 2_ESTIMATOR_SUPPLEMENT and 3_SURVEY_CODES.

- Orange cells are required.
- Yellow cells are optional.

- A blank cell takes the code value or the default.
- Do not edit the hidden key column.

Project. Required: Project Title, Road Name, Road Code (e.g. F123 or IR45), Region and District. Optional, for the title block: Client, Consultant, Designed by, Checked by, Approved by and Date. The Road Code names the output files.

Design data

Field	Default	Unit	Options and notes
Road type (required)	Feeder Road (DFR)		Trunk Road (GHA) · Feeder Road (DFR) · Rural Road. Proposes the design standard.
Design standard (override)	blank		GHA · DFR · TRL_ORN · AASHTO · DMRB · AUSTROADS
Area type (required)	Rural		Rural · Urban (urban maximum superelevation 5%)
Traffic count, AADT, opening year	blank	veh/day	
Design class	blank		A to E; blank = proposed from the AADT
Design speed	blank	km/h	Blank = proposed from the class and terrain
Speed level when proposed	Desirable		Desirable · Absolute
Maximum superelevation	blank	%	Blank = the code value
Surfacing (required)	DBST		AC · DBST · SBST · GWC · RIGID
Normal camber	blank	%	Blank = the code value for the surfacing
Number of lanes (required)	2		
Lane width (required)	3.25	m	
Shoulder width, each side (required)	1.0	m	
Minimum longitudinal grade (required)	0.5	%	GHA minimum 0.4%

Field	Default	Unit	Options and notes
Maximum longitudinal grade	blank	%	Blank = the code limit for the speed
Fill cover over culverts (required)	0.6	m	Default cover over proposed culverts
Cut side slope, 1V:nH (required)	1.0	n	
Fill side slope, 1V:nH (required)	1.5	n	
Profile datum	blank	m	Blank = automatic
Sag reprofiling: maximum added cut or fill depth (required)	1.0	m	Limits how far a sag may be reprofiled
Sag reprofiling: maximum increase in earthworks (required)	30	%	

Where the speed is not given, the DFR standard proposes 50, 40 or 30 km/h for level, rolling or mountainous terrain, with maximum grades of 6, 8 or 12%. TRL ORN proposes 70, 50 or 40 km/h, and AASHTO 80, 60 or 50 km/h.

Limits (overrides). You may override the minimum horizontal radius, stopping sight distance, crest and sag K, minimum vertical-curve length, runoff relative gradient, minimum horizontal curve length and minimum tangent between curves. Blank takes the code value for the design speed. An override is accepted, but the gates report it as REVIEW.

Culverts (up to 25 rows, optional). The form adds to the culverts found in the survey. A form row within 15 m of a surveyed culvert replaces its type, cover and size.

Column	What to enter
Chainage	m, km+m or km: 1200, 1+200 or 1.2 km
Proposed / Existing	Which it is
Family	Pipe · Box · U
Size	Cells and size, e.g. 900, 2/900, 2x900, 2.0x1.5, 2/2.0x1.5, 900X1200
Cells	Optional, if not in the size

Column	What to enter
Required fill cover	m; blank = the default cover
Notes	Free text

Accepted sizes: pipes 300–3000 mm, box spans 0.3–8 m and rises 0.3–6 m, 1–4 cells. A size the app cannot read is flagged, never guessed. The design does not size culverts: the size is yours.

Pavement and traffic

Field	Default	Unit
Subgrade CBR (required)	—	%
Sub-base CBR (required)	30	%
Base material (required)		crushed rock · granular base · stabilised gravel
Sub-base material (required)		natural gravel · stabilised gravel
Year-0 ESALs (required)	—	
Traffic growth rate (required)	5	%/yr
Design period (required)	15	years
Side-ditch storm return period (required)	10	years
Rainfall intensity	blank = from the region	mm/h

Sheet 2 — Estimator supplement. You only need this sheet when you want the design priced. A blank takes the estimator's default unless the note says otherwise.

- **Programme and existing road:** programme, existing carriageway width.
- **Earthworks:** reuse factor, the share of cut placed as fill (default 0.8).
- **Haul distances (km):** overhaul for sub-base and base; haul distances for sand, coarse aggregate, chippings and fill (the borrow pit); topsoil to stockpile; surplus cut to tip.
- **Binder rates (l/m²):** primer, first seal and second seal.

The app cannot know where the borrow pit or the tip is. **A blank topsoil, borrow or tip distance is not a nil.** It holds the bill until you give it. A distance of 1 km or less is a true nil, because the first kilometre is free haul.

The supplement's tables also carry:

- **Designed chainages:** where the design's earthworks replace the survey's. Blank means the whole road.
- **Township stretches.**
- **Vegetation:** thick, light, savannah, grass or existing bush.
- **Existing surface and condition:** GRAV or BIT; G, F, P, VP or NR.
- **Kerbs:** L, R or LR.
- **Scour checks and their spacing.**

4. The survey file

The survey is a point cloud. Each point has a plan position, a level and a code. The app reads it as you sent it, and stops to ask rather than guess when anything is ambiguous.

Format.

- A text file (.csv or .txt) with the columns id, easting, northing, elevation, code. Commas, semicolons, tabs or spaces are accepted.
- A header row is optional. The app finds the delimiter, any preamble and the columns.
- A raw GNSS export from the instrument is read directly.
- Files up to 40 MB are accepted.

Coordinates.

- Plan coordinates must be projected metres (for example UTM). The app does not transform coordinates or assume a datum.
- Columns named Easting and Northing are trusted.
- Columns named X and Y are checked against the values. If they are the wrong way round, the app swaps them and tells you.
- A file holding only latitude and longitude is refused. Convert it to projected metres before you upload.

Point codes. Codes can be upper or lower case, and a hyphen and an underscore mean the same. Put chainage, culvert size and status in their own columns, never inside the code.

Code	Meaning	Contoured
CL	Centreline	yes
L1 / R1	Edge of pavement, the first offset each side	yes

Code	Meaning	Contoured
L2, L3 … / R2, R3 …	Further offsets; survey out to about 20 m each side	yes
GL · SH · DRN	Ground level · spot height · drain	yes
CUL · CUL-E · CUL-P	Culvert centreline ground level · existing culvert · proposed culvert	yes
CUL-L1, CUL-R1 …	Culvert wings, numbered outwards	yes
INV · DRN-INV · CUL-INV	Inverts	no
BLD · EP · HT · STAY	Buildings, electricity poles, high-tension lines, stays	no
TBM	Benchmark / control, used for the setting-out schedule	no
BDY	Boundary	no

Older spellings still work, and the report lists each one used:

- cl, l, ll, lll, r, rr, rrr;
- clv, clvc for a culvert; exclvc for an existing one;
- clvl, clvll, clvr, clvrr for culvert wings;
- inv or invt for an invert; bd for a building.

A code the app does not recognise is never dropped. It goes on its own layer, outside the terrain model, and is listed for you.

Culverts in the survey. A culvert code without "ex" or "exist" is read as proposed, and an invert with no culvert nearby is read as an existing culvert. Where codes contradict each other, the app does not guess; it asks.

Auto-clean. Before measuring anything, the app:

- removes impossible rows;
- merges duplicate passes;
- corrects off-course centreline points and level spikes;
- flags kinks where the implied radius is below 50 m.

The report lists everything it changed. You can accept or reject each kink in the editors' survey-kink review.

5. The stages and the audit gates

A run passes through nine stages. Three of them are gates that check the design before it moves on.

Stage	What happens
R1 Survey & terrain	Reads and cleans the survey and builds the terrain model. Classifies the terrain, proposes the design class and speed, and finds the culverts. Its card shows length, terrain, mean ground grade, class, speed, maximum grade and culverts.
R2 Horizontal alignment	Fits curves through your centreline and applies superelevation and runoff
R3 Gate 1 — horizontal	Checks the horizontal alignment
R4 Vertical alignment	Designs the grade line for least earthworks within the grade, K-value and culvert-cover limits
R5 Gate 2 — vertical	Checks the vertical alignment
R6 Cross-sections & earthworks	Cuts sections and measures cut, fill and topsoil
R7 Ditches & pavement	Designs the side drains and the pavement
R8 Gate 3 — section, drainage, pavement	Checks the sections, drains and pavement
R9 Deliverables & estimator	Writes the drawings, workbook and report, and prices the design in the Road BOQ Estimator

Verdicts.

- **PASS:** the check meets the code.
- **REVIEW:** the run continues, but the check needs your attention. This happens when an override was used, when an absolute rather than desirable value was used, when a field check is needed, or when the speed was reduced.
- **FAIL:** a code violation. The app tries to revise the design.

Each gate card shows the counts (P / R / F), the iteration log, the geometry as accepted, and every check needing attention with its location, value, limit and clause.

What each gate checks

Gate	Checks
Gate 1 — horizontal	Radius against the minimum (below desirable is REVIEW); superelevation against its maximum and against the code value for the radius; runoff length; curve length; sight-line offset for stopping sight distance (REVIEW, field check); tangents long enough for both runoffs; broken-back curves (REVIEW); design speed within the class and terrain band; culverts on the chainage
Gate 2 — vertical	Grade against the maximum; grade against the drainage minimum (FAIL on a tangent in cut, REVIEW on fill); crest and sag K and vertical-curve length; no sag low point in cut (FAIL above 0.3 m deep); a cross culvert within 60 m of every sag low point; culvert cover; a curve hidden by a crest (REVIEW); runoff on a grade flatter than 0.4% (REVIEW)
Gate 3 — section, drainage, pavement	Lane and shoulder widths against the class (your inputs; only you can change them); camber; ditch capacity (FAIL) and velocity above 3 m/s (REVIEW); pavement structural number provided against required

A culvert that Gate 2 inserts at a sag is marked REVIEW: confirm its size, invert and outfall.

How the app revises a failing design. For up to seven iterations it changes the geometry:

- **Horizontal:** larger radii; curves merged or spaced further apart. The alignment may move up to 10 m off the surveyed centreline.
- **Vertical:** closer vertical intersection points; levels held over culverts; drainage grade forced on tangents in cut. Sag low points are reprofiled within your form's limits, then lifted out of cut. Failing that, a proposed 1/900 pipe is placed at ditch level.
- **Sections:** ditches enlarged, up to 1.2 m × 1.2 m; base thickened.

From the eighth iteration, the app lowers the design speed in 10 km/h steps, only over the failing sections. It never goes below the lowest speed the code allows, and never below 30 km/h. Where the drop is more than 20 km/h below the neighbouring sections, it adds 200 m transition zones at the intermediate speed on each side. Every reduced zone is listed under **Posted speed-limit zones**, with the speed-limit (R 811.3) and warning (R 811.1) signs counted into the bill. The app never changes your own inputs.

Referred to the designer. If a failure can be cleared only by changing your inputs, or the design does not converge, the run stops. It shows "Referred to the designer", with the reason, the failures left and what was tried. Typical reasons:

- "only a change to your inputs can clear: …"
- "not converged after 7 geometric iterations"
- "failures that lowering the design speed (down to the code's lowest) cannot clear: …"
- "no convergence after 60 iterations"

Change the inputs, or use the editors, and run again from the stage named.

6. Design rules you should know

Centreline. A surveyed CL point is the centreline. L and R points are offsets from it. The midpoint of the edges, (L + R) / 2, is used only to bridge a kink or a gap:

Gap between CL points	How it is bridged
under 30 m	CL points only
30–50 m	a straight chord
50–100 m	the edge midpoint
over 100 m	referred to you

Terrain is classified from the mean grade along the centreline.

Culverts.

- **Proposed culverts:** the invert is set at side-ditch level, 0.6 m below ground. The formation is kept at least the cover above the barrel.
- **Existing culverts:** the formation is kept the cover above the existing level, 0.3 m by default.
- **Near culverts and valleys:** the grade is not cut within 100 m of a culvert or valley.
- **Sizing:** the app does not size culverts hydraulically. Their size comes from your form or survey.

Vertical alignment.

- **Earthworks:** the grade line is solved for least earthworks within the maximum and minimum grades, the K values and the culvert cover.
- **Curve length:** each vertical curve is the longer of K × the grade change and the code minimum.

- **Breaches:** a grade breach is flagged at the gate, never refused.

Side drains.

- **Standard ditch:** a V-ditch 0.6 m deep (fore slope 1:2, back slope 1:1, 1.8 m across the top).
- **Cut and embankment:** a 1 m berm is formed in cut. Embankment sections get no side drain.
- **Capacity:** where the ditch is too small, it steps up to a trapezoidal drain (0.6 m, then a 1.0 m stone-lined base). In cuts over 1 m deep, it steps up to a concrete U-drain.
- **Lining:** unlined earth is limited to 1.1 m/s and stone lining to 4.5 m/s.
- **On the drawings:** every cross-section names its drain.

Pavement.

- **DFR, TRL ORN and GHA standards:** the pavement comes from the ORN 31 (5th edition) structural catalogue, Chart A1.
- **AASHTO, DMRB and AUSTROADS:** the pavement is designed by AASHTO-93.
- **Thicknesses:** sub-base and base are rounded up to the next layer the bill can price: sub-base 100, 150, 200 or 250 mm; base 150, 200 or 250 mm.
- **Referred instead:** a thicker design, another ORN 31 chart, or a weak subgrade that needs capping.

Earthworks. Volumes are measured by end areas between sections.

- **Reuse:** cut placed as fill is the cut × the reuse factor (0.8), up to the fill needed.
- **Borrow and spoil:** borrow makes up the rest of the fill, and surplus cut goes to spoil. No bulking factor is applied.
- **Topsoil:** stripped 150 mm deep over the width of the cross-section.
- **Beyond the survey:** sections reach 20 m each side. Where the survey does not reach that far, ground beyond it is taken as a flat plane, and the report says how much of the volume depends on it.

Haulage.

- **Free haul:** the first kilometre of each movement is free.
- **Cut-to-fill:** the distance is found from the mass haul.
- **Borrow, topsoil and tip:** the distances come from your supplement sheet. A blank one refers, as in section 3.

7. Outputs and downloads

The **Deliverables** card lists every file, with **Download everything (ZIP)** at the top. In the file names, `<code>` is the Road Code (or the road name), up to 16 characters.

Drawings (A3 PDF)

File	What it shows
DRG-01_Topo_Plan_Contours.pdf	Topographic plan with contours, in 1:2000 strips
DRG-02_Horizontal_Alignment.pdf	The horizontal alignment and its curve schedule
DRG-03_Existing_Ground_Profile.pdf	The existing ground along the centreline
DRG-02A_Grade_Line_Phase1.pdf	The first-phase grade line
DRG-02_Longitudinal_Profile.pdf	The designed profile, horizontal 1:2000 and vertical 1:200, with culverts marked
DRG-03_Cross_Sections.pdf	Cross-sections, each naming its drain
`<code>`_Plan_Profile.pdf	Plan and profile together

CAD exchange files

- `<code>`_plan_layers.dxf: every surveyed point on its layer (surface, drainage, assets, control, boundary, culverts, unrecognised), with code labels and the surveyed centreline.
- `<code>`_civil3d.xml: a LandXML 1.2 file with the survey points, the ground surface, the designed alignment and the ground and design profiles.
- Open both files in your own CAD package and check them before you rely on them.

Workbooks and report

File	What it holds
`<code>`_Workbook.xlsx	Design controls, vertical alignment, profile stations, side ditches, pavement, cross-sections and the quantity take-off
`<code>`_SettingOut.xlsx	Centreline setting-out, curve data and the control benchmarks

File	What it holds
`<code>`_Report.docx	The design report: survey and terrain (including code changes, culvert inverts, survey coverage and the questions for the Engineer), design controls, vertical alignment, drainage, pavement, preliminary quantities, data still required, and the register of drawings
horizontal_curves.csv · `<code>`_Culvert_Schedule.csv	The curve schedule and the culvert schedule

The workflow records are also listed: each gate's verdict, the speed-limit schedule, the referral (if any), the run log and the estimator hand-off.

Drive-through videos. The plan drive and the drive-through play on the page and can be downloaded as .mp4 files.

Projects are kept for 7 days, so download the ZIP when the design is done.

8. Hand-off to the Road BOQ Estimator

At R9 the app writes a survey workbook for the estimator, `<code>`_Estimator_Input.xlsx, and has it priced. Both of the estimator's engines price it. The priced client bill, BOQ_client.xlsx, comes back with the deliverables. The run also appears in your Road BOQ Estimator account.

What is handed over

- **Road data:** carriageway, shoulder, seal and prime widths; the sub-base and base thicknesses as designed; and the haul distances and binder rates from your supplement sheet.
- **Design earthworks:** topsoil strip, cut, cut placed as fill, borrow and spoil.
- **Designed haulage:** cut-to-fill, borrow, topsoil and spoil, each with its distance, so the estimator can band each one.
- **Speed-limit and warning signs** for the reduced-speed zones.
- **Side ditches, kerbs and scour checks;** the existing surface and its condition; vegetation and township stretches.
- **Culverts:** each one, proposed or existing, with its family, cells, size and a barrel length from the formation width and fill height. An unreadable size is priced as a 1/900 pipe and flagged.

The **R9 · Road BOQ Estimator** card shows the main quantities (topsoil, cut, reuse, borrow, spoil and haulage), the priced total, whether the two engines agree, and any work measured but not yet priced.

Either/or. Over the designed chainages, the design's earthworks replace the survey's. Elsewhere the survey's earthworks apply as before. The two are never compared or forced to agree: a condition survey's earthworks are a conservative estimate, and the design's are measured. In the estimator's bill, design quantities appear in the Re-alignment column.

A provisional bill. If a borrow, topsoil or tip distance is blank, or a quantity is referred, the priced total is provisional. The log says so, even when both engines agree. Supply the missing data and run again.

9. Limits, messages and troubleshooting

Limits.

- **Preliminary only:** the design must be checked and sealed by a licensed civil engineer.
- **Hydraulics:** culvert and bridge hydraulics are out of scope. Culvert sizes are yours.
- **Pavement:** only ORN 31 Chart A1 is carried. Other charts and weak subgrades are referred.
- **Section extent:** cross-sections reach 20 m each side. Ground beyond the survey is assumed flat, and the report says how much this affects.
- **Drain sizing:** the catchment for drain sizing is the carriageway plus a 5 m strip.
- **Culverts close together:** culverts within 15 m of each other are treated as one.
- **Run time:** a run stops after 30 minutes at any one stage.

Messages when you upload or run

Message	What to do
Choose the input form and the survey file	Select both files before pressing Upload and run
… exceeds 40 MB	Split the survey, or remove points you do not need
The input form could not be read: …	Use the current template, saved as .xlsx
Input form incomplete: … / Missing: …	Fill in the orange cells named
Design standard '…' is not one the engine carries … / Road type '…' is not one of: …	Choose from the lists on the form

Message	What to do
LIMITS override … is not a number	Correct the override, or leave it blank
Culvert chainage … cannot be read / Culvert at …: …	Correct the culvert row: chainage, size range or cells (1–4)
this project is already running	Wait for the run to finish
Project not found	Check the project id. Projects are deleted after 7 days.
Stopped on an error - see the run log.	Read the log. If the cause is not clear, send the project id to Bespa support.

Messages about the survey file

Message begins	What to do
no column in that file holds survey codes …	Add the code column
no two columns in that file look like plan coordinates in metres …	Export projected coordinates (e.g. UTM) in metres
no column in that file carries levels that vary like ground does …	Check the elevation column
the only plan coordinates in this file are latitude and longitude …	Convert the survey to projected metres and upload again
that is an old-format Excel file (.xls) … / that is a zip archive …	Send the survey itself, as .csv or .txt
the file read perfectly … but not one of its … codes is recognised …	Use the survey codes in section 4
this file cannot be read without a decision that changes the design …	Resolve the ambiguity named, and run again

Common situations

You see	What to do
A gate shows REVIEW	Read each REVIEW item, and check the field items on site. The design continues.

You see	What to do
"Referred to the designer"	Read the reason. Change the inputs, or adjust the design in the editors, and run again from the stage named.
Speed-limit zones are posted	The road could not meet the code at the design speed there. Accept the zones or change the inputs.
The estimator total is provisional	Give the borrow, topsoil and tip distances on the supplement sheet, and run again from R1
A culvert was inserted at a sag	Confirm its size, invert and outfall, and add it to the culvert table if you keep it